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FOSSIL ENERGY

SUPPORT STUDIES BY SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY

CO_2 Acceptor Process Gasification Pilot Plant

Final Report, February 1971—January 1978, Book 2 of 2 Appendices

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SUPPORT STUDIES BY SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY

CO_2 ACCEPTOR PROCESS GASIFICATION PILOT PLANT

FINAL REPORT, VOLUME 9
BOOK 2 OF 2, APPENDICES
PERIOD: FEBRUARY 1971 - JANUARY 1978

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APPENDIX A

DETAILED SURFACE SECTIONS

The detailed surface section logs presented in this appendix are described in Subsection 5.1 in Book 1 of this volume.

Surface Section - Jefferson Formation

LOGAN, MONTANA

Gallatin County, Montana

Section in SE 1/4, Sec. 25, T2N, R2E

North bank of Gallatin River, cliffs.

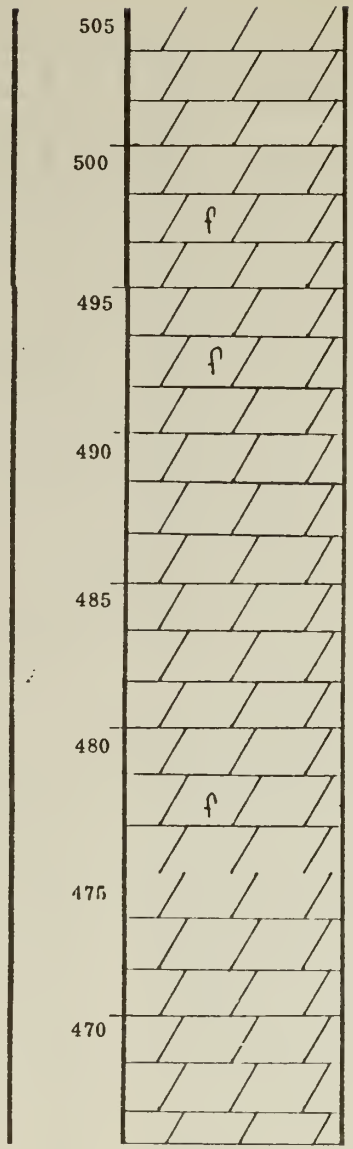
Vertical scale: 1" to 5'

Dept. of Geol. & Geol. Eng., S.D.S.M. & T. 7/73

By: J.C.M., T.H., S.O.

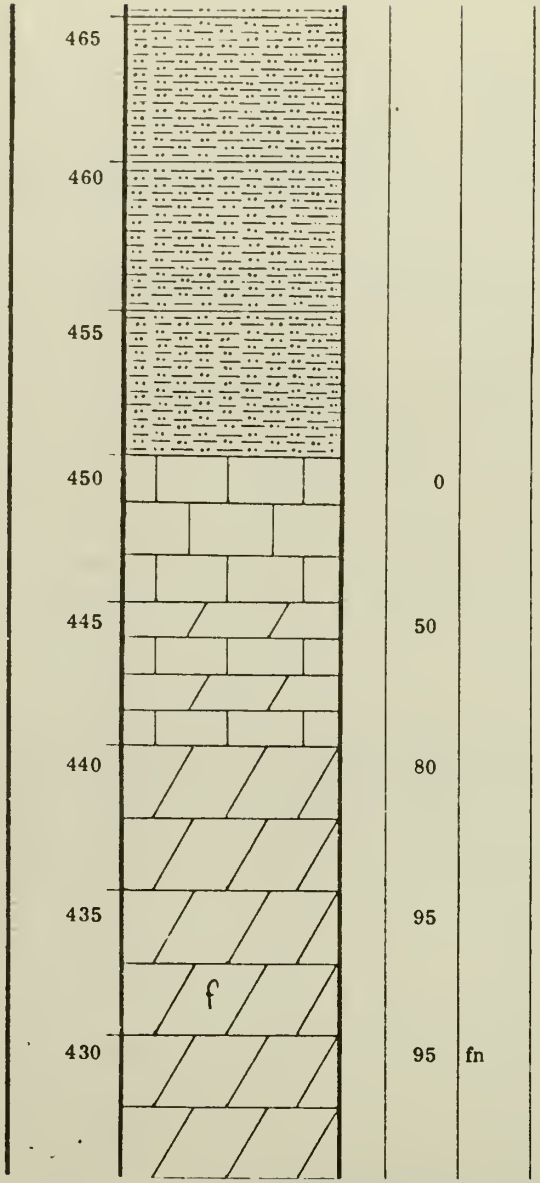
		% Dolo.	Grain Size	
515				Section covered. Probable top of Jefferson Fm. at 515 feet.
510				Section covered

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 1 of 14)



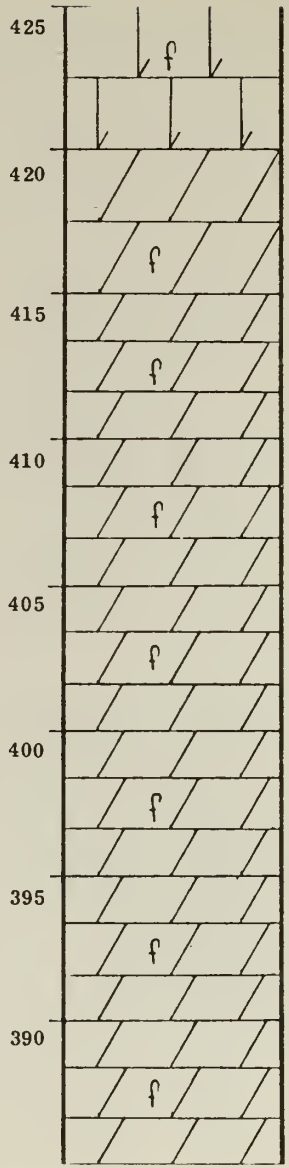
100	v. fn	Dj #99: Dolomite, light pale brown. Weathers tan. Very fine crystalline to sucrosic. Some calcite in cracks; iron stain.
100	fn	Dj #98: Dolomite, light and medium gray to white. Weathers tan-brown. Fine crystalline to sucrosic. Mottled coloration; recrystalized fossils.
100	v. fn-med	Dj #97: Dolomite, medium and dark gray. Weathers tan-brown. Very fine sucrosic. Mottled coloration; recrystalized fossils.
100	v. fn	Dj #96: Dolomite, medium gray. Weathers tan-brown. Very fine sucrosic, dense. Calcite along cracks.
100	fn	Dj #95: Dolomite, medium gray. Weathers brown-tan. Fine sucrosic, dense. Calcite along cracks.
100		Dj #94: Dolomite, light and medium gray. Weathers to brown. Dense. Recrystalized fossils; very shattered; mottled coloration; iron stain.
100	fn	Dj #93: Dolomite, light to medium gray. Weathers dirty brown. Very fine crystalline to sucrosic. Calcite along cracks and in vugs; mottled coloration.
100		Dj #92: Dolomite, light and medium gray. Weathers brown. Sucrosic. Sheared; shattered; calcite in cracks; mottled coloration.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 2 of 14)



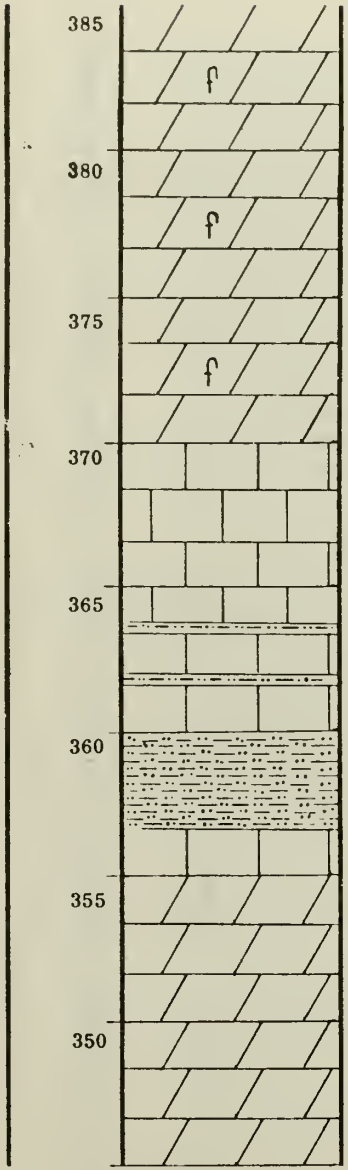
		Dj #91: Siltstone, pinkish orange to yellow. Weathers covered. Color mottled; texture uniform. Measures 16 feet of section.
		See Dj #91
		See Dj #91
450	0	Dj #90: Limestone, light brown. Weathers light yellow. Crystalline to sucrosic. Crystalline calcite and sucrosic limestone; very porous.
445	50	Dj #89: Calcitic dolomite, rusty white and light brown-gray. Weathers tan-brown. Crystalline. Highly sheared in at least two planes; fractures calcite filled; some silty layers and spots.
440	80	Dj #88: Calcitic dolomite, light gray to brown. Weathers mottled tan-brown. Sucrosic. Porous; uniform texture and color.
435	95	Dj #87: Dolomite, light and medium gray. Weathers light tan-brown. Sucrosic. Stylolitic calcite; recrystalized fossils (calcite); iron stain.
430	95 fn	Dj #86: Dolomite, light and medium gray. Weathers gray-brown. Sucrosic to fine crystalline. Mottled; solution features such as stylolites; porosity.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 3 of 14)



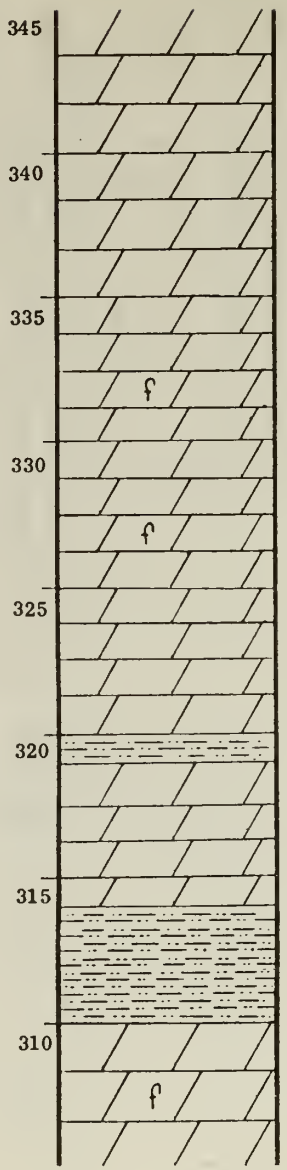
50	fn-med	Dj #85: Calcitic dolomite, yellow to whitish gray. Weathers tan. Fine to medium crystalline to sucrosic. Highly sheared; calcite veins; large fractures; recrystalized fossils; iron stain.
95		Dj #84: Dolomite, yellowish-gray. Weathers gray-tan. Sucrosic. Yellow mottled; calcite along fractures; sheared; iron stain; some porosity; recrystalized fossils.
85		Dj #83: Calcitic dolomite, light and medium gray. Weathers tan-brown. Sucrosic. Sheared; porous; recrystalized fossils; calcite along fractures.
95	fn	Dj #82: Dolomite, brownish gray. Weathers brown. Sucrosic to fine crystalline. Mottled; calcite in vugs; iron stains; recrystalized fossils; weathers with pocked and pitted surface.
95	fn	Dj #81: Dolomite, light to medium gray. Weathers brown. Fine crystalline. Some recrystalized fossils; platey; sheared.
95	fn	Dj #80: Dolomite, medium to dark gray. Weathers brown. Sucrosic to fine crystalline. Fractures with calcite; fossil fragments.
95		Dj #79: Dolomite, medium and dark gray. Weathers brown. Sucrosic. Yellowish-gray calcite fossil fragments give orange mottled appearance; small cracks.
95	fn	Dj #78: Dolomite, medium and dark gray. Weathers brown. Sucrosic to fine crystalline. Crinoid fragments; calcite on fractures; iron stain; mottled, medium gray is more sucrosic.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 4 of 14)



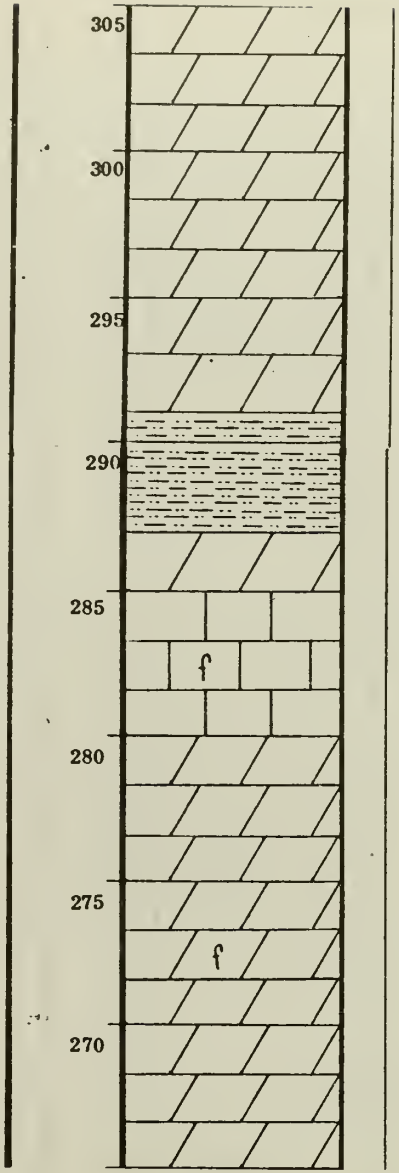
385	100	fn	Dj #77: Dolomite, dark gray. Weathers brown. Sucrosic to fine crystalline, brecciated. Fractures with yellowish calcite lining them; crinoids.
380	100	fn	Dj #76: Dolomite, tones of gray and orange. Weathers brown. Sucrosic to fine crystalline. Crinoids; calcite on fractures; mottled; iron stained; sheared.
375	95		Dj #75: Dolomite, yellow gray and medium gray. Weathers light gray and yellow brown. Sucrosic. Fossil parts (crinoids); mottled; shattered; sheared.
370	5		Dj #74: Magnesian limestone, light gray and yellow. Weathers brown. Sucrosic. Sheared; fractured; mottled; calcite on fractures; some porosity.
365	5	fn	Dj #73: Magnesian limestone, gray and yellow. Weathers gray. Fine crystalline. Pin point porosity; some fine grained yellow clay.
360			Dj #72: Bottom 2', limestone, light gray. Weathers gray. Breccia. Porous; iron stains. Top 3', calcareous clay-siltstone, yellow. Some mica and chert pebbles.
355	90	fn	Dj #71: Dolomite, light to dark gray. Weathers brown. Fine crystalline. Sheared and brecciated with calcite.
350	100	v. fn	Dj #70: Dolomite, medium gray. Weathers brown. Very fine crystalline.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 5 of 14)



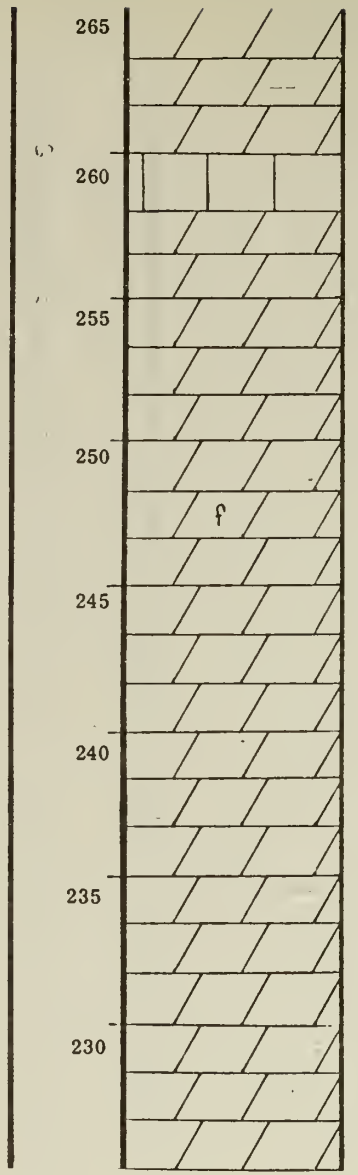
100	v. fn	Dj #69: Dolomite, light and dark gray. Weathers gray-brown. Very fine crystalline. Fractures with calcite; shattered; sheared.
95	v. fn	Dj #68: Dolomite, light and dark gray. Weathers light brown. Very fine crystalline. Mottled; iron stained; calcite along fractures.
95	fn	Dj #67: Dolomite, medium gray. Weathers brown. Dense, fine crystallin Tough; calcite on fractures; fossils in part recrystalized but sucrosic not crystalline.
95	fn	Dj #66: Dolomite, medium gray. Weathers gray to brown. Fine crystalline. Shell casts and partially recrystalized fossils; slightly argillaceous.
95	fn	Dj #65: Dolomite, light and dark gray. Weathers brown. Fine crystalline. Mottled; slightly argillaceous; vuggy; calcite on fractures.
90	fn	Dj #64: Dolomite, light gray. Weathers brown except light colored chert. Fine crystalline. Biosparite; light rust and gray mottled; shattered; sheared. Top 1', siltstone.
		Dj #63: Bottom 4', siltstone, yellow-brown. Weathers rusty yellow-brown. Calcite along fractures; calcite and dolomite cement. Top 1', dolomite, medium gray. Weathers gray-brown. Fine crystalline, dense.
90	fn	Dj #62: Dolomite, light and dark gray mottled. Weathers brown. Fine sucrosic. Biosparite; silica seen in thin section; amphipora.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 6 of 14)



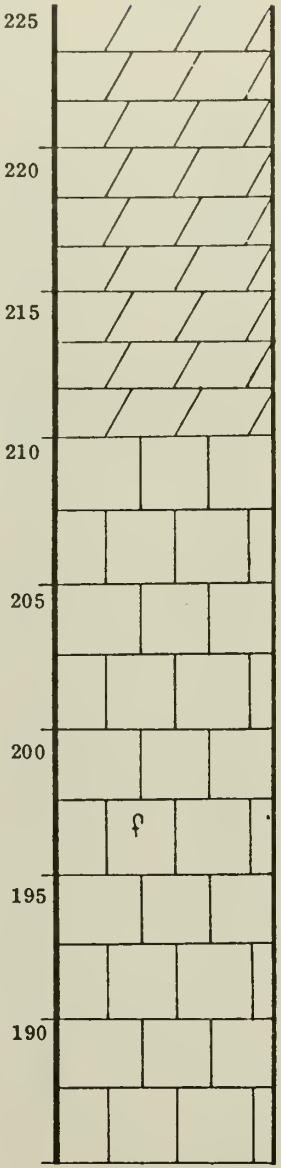
90	fn	Dj #61: Dolomite, dark gray and yellow-gray. Weathers brown-gray. Fine crystalline. Biosparite; ovate calcite pockets - possibly after fossils.
90	fn	Dj #60: Dolomite, dark gray. Weathers light brown. Fine crystalline. Calcite filled fractures.
		Dj #59: Top of #58, bottom of #59, 3' yellow silty layer, weathers rusty orange-brown. Calcite filled fractures and cement. Rest of #59, dolomite, dark gray. Weathers brown. Fine crystalline. Calcite in fractures; biosparite; mottled coloration.
75		Dj #58: Calcitic dolomite, light and medium gray. Weathers light brown. Light gray sucrosic, medium gray crystalline. Biosparite; manganese dendrites.
25		Dj #57: Dolomitic limestone, light and dark gray. Weathers brown. Very sucrosic. Very porous; light gray calcite; dark gray dolomite; brecciated; calcite in fractures; biosparite and fossils; sheared; algae-like swirls.
80		Dj #56: Calcitic dolomite, light and dark gray. Weathers light brown. Sucrosic and crystalline, pelletal. Calcite filled fractures; recrystallization in progress; algae-like swirls.
65		Dj #55: Calcitic dolomite, light and dark gray. Weathers light brown. Sucrosic. Vugs; fossil fragments; biosparite; pin point porosity. Weathers pitted and pocked.
65		Dj #54: Calcitic dolomite, light and dark gray. Weathers gray-brown. Sucrosic, crystalline, pelletal. Mottled - light is limestone, dark is dolomite; some calcite in fractures and veins.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 7 of 14)



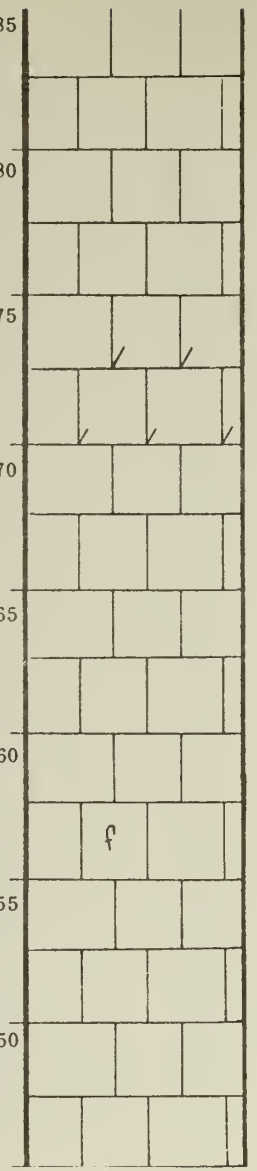
265	75		Dj #53: Calcitic dolomite, gray. Weathers gray-brown. Sucrosic to crystalline. Calcite filled fractures.
260			Dj #52: Lower 3', dolomite, light and dark gray. Weathers gray. Fine sucrosic. Calcite and chalcedony in vugs; fractured; color differences in dolomite. Top 2', limestone.
255	75		Dj #51: Calcitic dolomite, medium gray. Weathers brown. Sucrosic. Calcite filled vugs and fractures; biosparite.
250	100	fn	Dj #50: Dolomite, light and dark gray. Weathers brown. Fine sucrosic. Calcite in vugs; chalcedony in spaces; recrystalized fossils; fractured; sheared; mottled coloration. Some clay and organic matter seen in thin section.
245	100	fn	Dj #49: Dolomite, medium gray. Weathers brown. Fine sucrosic. Mottled coloration; fractured; sheared.
240	100	v. fn	Dj #48: Dolomite, medium gray. Weathers brown. Fine sucrosic. Weathers with a pocked and pitted surface.
235	60		Dj #47: Calcitic dolomite, dark gray. Weathers to brown. Sucrosic. Porous; mottled light, medium and dark gray.
230	100	fn	Dj #46: Dolomite, dark gray. Weathers brown. Fine sucrosic. Patches of white calcite; weathers pitted, pocked, rough.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 8 of 14)



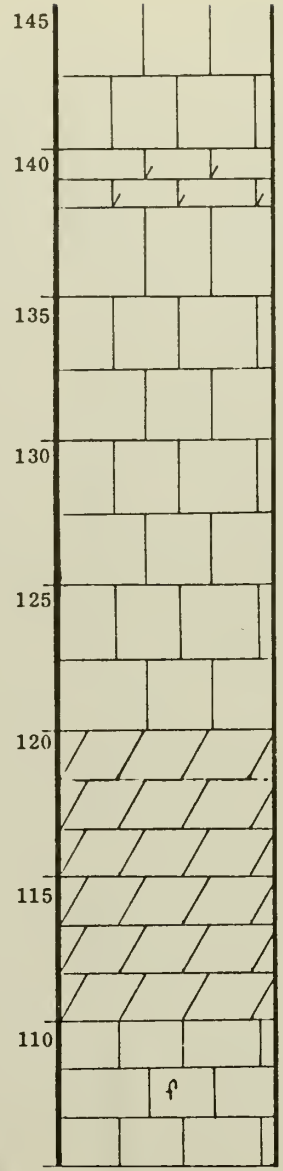
100	fn-med	Dj #45: Dolomite, dark gray. Weathers brown. Sucrosic to medium crystalline. Patches of white calcite; blue opal filled pores and vugs.
60	fn-med	Dj #44: Calcitic dolomite, medium gray. Weathers brown. Sucrosic to coarse crystalline. Porous with some blue opal filling. Weathers very rough, pocked and pitted.
100	fn	Dj #43: Dolomite, steel to dark gray. Weathers rusty brown. Fine sucrosic to crystalline. Porespaces filled with calcite and blue chalcedony. Dramatic change in color in this interval, gray-tan to brown.
		UPPER - LOWER JEFFERSON CONTACT
		Dj #42: Limestone, medium gray. Weathers light gray-brown. Dense, sucrosic. Sheared; mottled coloration; weathered.
		Dj #41: Limestone, medium to dark gray. Weathers gray. Dense, sucrosic. Mottled coloration; crystalline calcite veinlets; open spaces; fossils and pellets seen in thin section; laminated.
		Dj #40: Limestone, medium gray. Weathers gray-brown. Dense, sucrosic to fine crystalline. Brachiopods, some dark gray inclusions.
		Dj #39: Limestone, medium gray. Weathers gray-brown. Sucrosic. Tough; sheared.
		Dj #38: Limestone, medium gray. Weathers gray-brown. Dense, sucros Sheared, some darker gray inclusions.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 9 of 14)



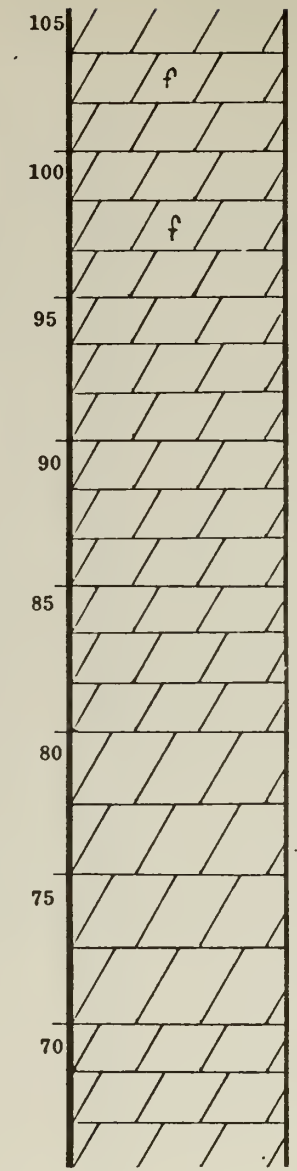
		Dj #37: Limestone, medium gray. Weathers gray-brown. Sucrosic. Sheared; some color change from laminae to laminae.
		Dj #36: Limestone, dark gray. Weathers gray-brown. Dense, sucrosic. Mottled brown of various hues.
5	v. fn-fn	Dj #35: Magnesian limestone, dark to medium gray. Weathers brown. Dark gray is dense, lighter gray is sucrosic. Calcite veinlets; crystalline calcite inclusions. Few dolomite rhombs seen in thin section.
		Dj #34: Limestone, dark gray. Weathers black, brown, gray. Dark gray is dense, lighter gray is sucrosic. Thin laminated; mottled coloration.
		Dj #33: Limestone, dark gray. Weathers to dark gray. Dense. Jointed with rusty coloration on surfaces; sheared; calcite veins.
		Dj #32: Limestone, dark gray. Weathers to light gray. Dense. Fossils including brachiopods; weathers with pocked surface.
		Dj #31: Limestone, dark gray almost black. Weathers to gray-brown. Dense. Sheared; shattered; weathers with pocked surface.
		Dj #30: Limestone, dark gray-brown. Weathers to gray-brown. Very dense. Sheared; jointed.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 10 of 14)



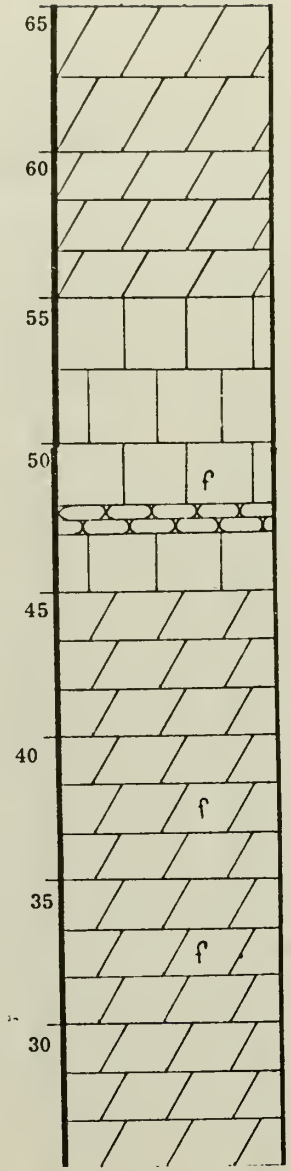
		Dj #29: Limestone, dark gray. Weathers to gray-brown. Dense. Sheared and shattered.
		Dj #28: Lower 3' limestone, dark gray-brown. Weathers gray. Medium crystalline. Platy fracture system. Upper 2' dolomitic limestone, light gray. Weathers light gray-brown. Very dense. Very porous and permeable.
		Dj #27: Limestone, medium gray. Weathers gray to light brown. Sucrosic with some porespace. Shattered; sheared; weathers with pocked surface.
		Dj #26: Limestone, dark gray. Weathers gray or light brown. Dense, some porosity. Shattered; sheared; calcite veins.
		Dj #25: Limestone, dark gray. Weathers light gray to gray. Dense, silty texture. Calcite on fractures; breaks evenly.
90	med	Dj #24: Dolomite, color is a dark gray. Weathers gray-brown. Medium crystalline. Fractured, breaks on uneven surfaces; calcite blobs.
60	fn	Dj #23: Calcitic dolomite, medium to light gray. Weathers to gray-brown. Fine Sucrosic. Color varies from brown to gray in outcrop. Bands of lighter colored calcite; solution vugs; calcite filled vugs.
		Dj #22: Limestone, dark gray to black. Weathers light gray to brown. Dense to fine crystalline. Rock black with disseminated light colored limestone; abundant amphipora.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 11 of 14)



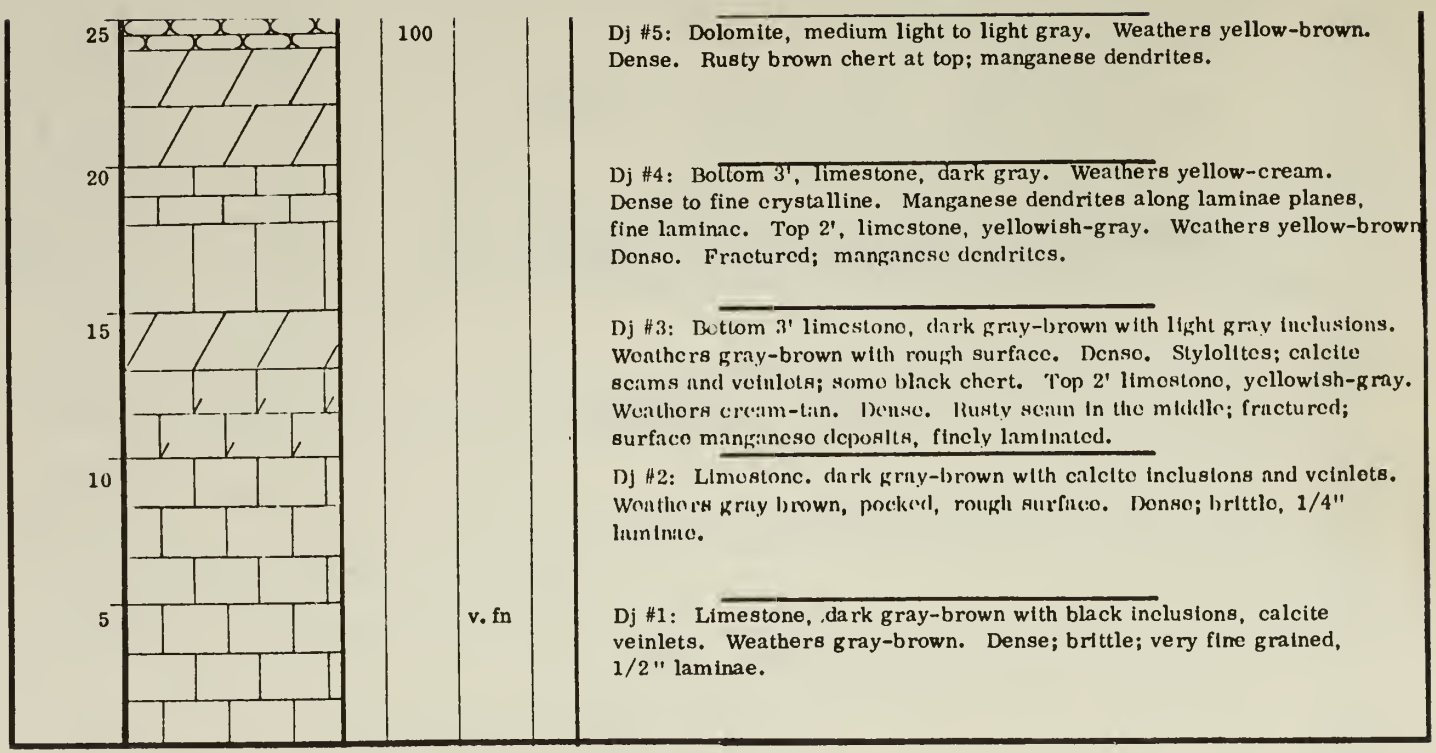
50	fn	Dj #21: Calcitic dolomite, dark gray. Weathers light gray-brown. Sucrosic. Fractured; abundant amphipora.
100	fn-med	Dj #20: Dolomite, light gray. Weathers gray-brown. Fine to medium sucrosic. Calcite vugs; some amphipora.
100	fn-med	Dj #19: Dolomite, dark gray. Weathers brown. Medium sucrosic. Fractured.
100	fn	Dj #18: Dolomite, dark gray. Weathers brown. Sucrosic, very uniform. Tough; calcite veins and vugs.
100	fn	Dj #17: Dolomite, dark gray. Weathers brown. Fine sucrosic. Calcite on fractures; very vuggy, filled with calcite and quartz.
100	v. fn-fn	Dj #16: Dolomite, dark gray. Weathers brown-gray. Fine sucrosic, some areas with two grain sizes. Calcite on joints and cracks; vugs with chalcedony, blue chert and calcite.
100	fn	Dj #15: Dolomite, dark gray. Weathers brown-gray. Fine sucrosic. Calcite in vugs and joints; some vugs filled with calcite covered chalcedony. Finely jointed.
100	fn	Dj #14: Dolomite, dark gray. Weathers brown-gray. Fine sucrosic, very uniform. Quartz and calcite veins.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 12 of 14)



100		Dj #13: Dolomite, medium gray. Weathers brown. Sucrosic. Some concentrations of calcite; shattered; sheared; jointed.
100	fn	Dj #12: Dolomite, medium gray. Weathers gray-brown. Fine sucrosic. Tough; vugs- quartz, calcite and empty.
		Dj #11: Limestone, dark gray. Weathers gray-brown. Fine crystalline to dense. White calcite zones; gray zones probably dolomite.
		Dj #10: Limestone, light gray to dark gray almost black. Weathers gray-brown. Dense. Black chert; calcite filled vugs; amphipora.
60	fn	Dj #9: Calcitic dolomite, medium gray. Weathers light brown. Fine sucrosic. Sheared; calcite veinlets; vugs with quartz; some black chert.
100	fn	Dj #8: Dolomite, dark gray. Weathers brown. Sucrosic. Quartz and calcite filled vugs; quartz veinlets; amphipora.
95		Dj #7: Dolomite, medium gray. Weathers gray-brown. Fine sucrosic. Sheared; veinlets of calcite; manganese dendrites; amphipora.
90		Dj #6: Dolomite, light gray. Weathers light brown. Fine sucrosic. Sheared; crystalline calcite in veins and along fractures.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 13 of 14)



Dj #5: Dolomite, medium light to light gray. Weathers yellow-brown. Dense. Rusty brown chert at top; manganese dendrites.

Dj #4: Bottom 3', limestone, dark gray. Weathers yellow-cream. Dense to fine crystalline. Manganese dendrites along laminae planes, fine laminae. Top 2', limestone, yellowish-gray. Weathers yellow-brown Dense. Fractured; manganese dendrites.

Dj #3: Bottom 3' limestone, dark gray-brown with light gray inclusions. Weathers gray-brown with rough surface. Dense. Stylolites; calcite seams and veinlets; some black chert. Top 2' limestone, yellowish-gray. Weathers cream-tan. Dense. Rusty seam in the middle; fractured; surface manganese deposits, finely laminated.

Dj #2: Limestone. dark gray-brown with calcite inclusions and veinlets. Weathers gray brown, pocked, rough surface. Dense; brittle, 1/4" laminae.

Dj #1: Limestone, dark gray-brown with black inclusions, calcite veinlets. Weathers gray-brown. Dense; brittle; very fine grained, 1/2" laminae.

JEFFERSON FORMATION SECTION, LOGAN, MONTANA (Sheet 14 of 14)

Surface Section - Madison Group

LOGAN, MONTANA

Gallatin County, Montana

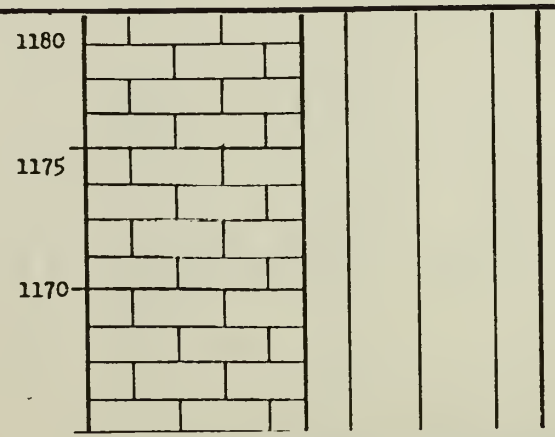
Section in SE 1/4, Sec. 25, T2N, R2E

North bank of Gallatin River, cliffs,

Vertical scale: 1" to 5'

Dept. of Geol & Geol. Eng., S.D.S.M. &T. 7/73

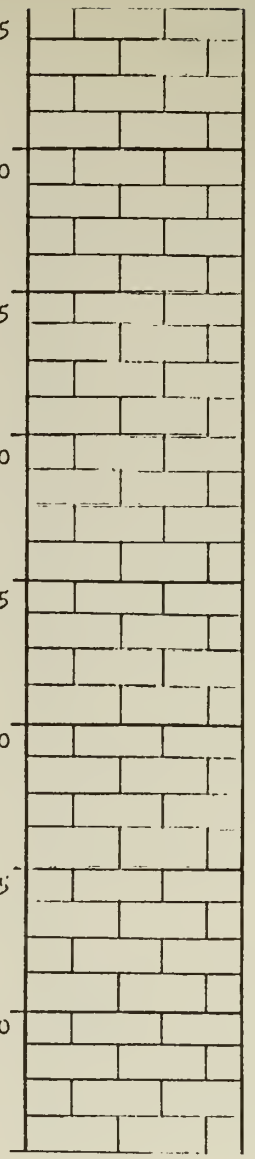
By: J.C.M., T.H., S.O.



Mmc #160: Limestone, light brown, weathers gray, dense, micritic. Calcite seams and spots. Black specks-probably organic debris.

Mmc #159: Limestone, light brown, weathers gray, dense, micritic. Calcite spots, seams. Probably relict fossil debris.

Mmc 158: Limestone, light brown, weathers gray, very dense, micritic. Relict fossil outlines, calcite seams and spots. Sheared.



Mmc #157: Limestone, light brown, weathers gray, dense, micritic, faint indication of pellets. Sheared, small calcite veins.

Mmc #156: Limestone, light brown, weathers gray. Dense micritic, with pellets. Calcite seams, pink.

Mmc #155: Limestone, brown, weathers light gray. Very dense micritic. Pink calcite seams. Poor exposure.

Mmc #154: Limestone, brown, weathers light gray. Very dense micritic. Sparry calcite blebs and patches. Possible fossil relicts. Poor exposure.

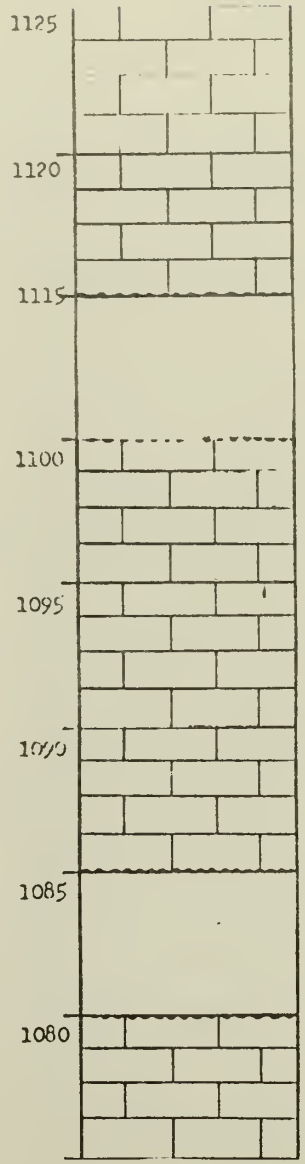
Mmc #153: Limestone, brown, weathers light gray. Very dense, micritic. Calcite seams and blebs. Sheared. Poor exposure along ridge top.

Mmc #152: Limestone, brown-gray, weathers gray. Very dense, micritic. Large calcite blebs and seams. Poor exposure.

Mmc #151: Limestone, light brown-gray, weathers gray. Very dense, micritic, Calcite blebs and seams. Sheared and shattered.

Mmc #150: Limestone, brown, weathers gray, very dense, micritic. Calcite veins 1/8 " across. Sheared. Platy.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 2 of 23)



Mmc #149: Limestone, light brown, weathers gray, dense, micritic. Almost lithographic. Few calcite blebs. Top of flat topped ridge. Poor exposures.

Mmc #148: Limestone, gray brown, weathers light gray. Very dense, micritic, with blebs of calcite. Sheared. Poor exposure.

Covered, 15 feet. From 1100 to 1115.

Mmc #147: Limestone, light tan-brown, weathers gray, dense, lithographic, micritic, black specks, probably organic material. Sheared. Hard. Poor exposure.

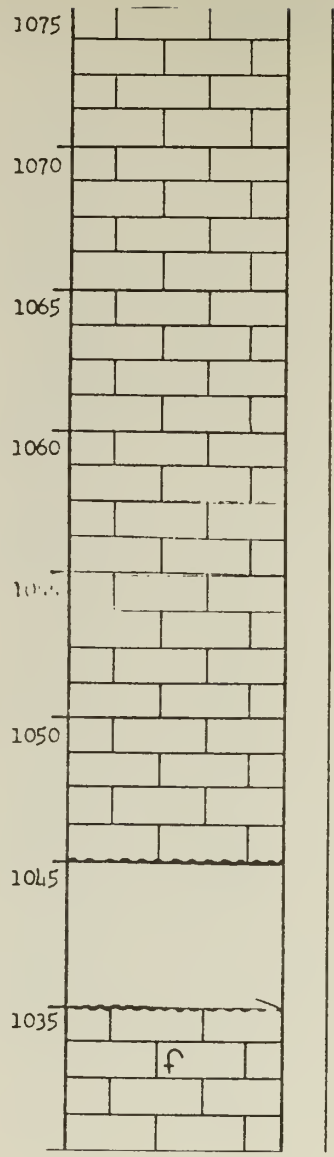
Mmc#146: Limestone, light gray-brown, weathers light gray. Dense, micritic. Very fine, lithographic. Sheared, calcite filled veinlets. Poor exposure.

Mmc #145: Limestone, light tan-brown, weathers light gray. Very dense, sub-lithogrphic, micritic. Bottom 5' covered. Very poor exposure.

5 feet covered.

Mmc #144: Limestone, light gray, weathers gray-white. Fine crystalline to micritic. Very poor exposures. Seems tough.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 3 of 23)



Mmc #143: Limestone, light gray-brown, weathers gray-tan, sparry . Fine crystalline, micritic. Very poor exposure.

Mmc #142: Limestone, light gray-brown, weathers gray-tan. Sparry calcite. Very weathered sample. Beds appear 2-3 feet thick. Medium crystalline.

Mmc #141: Limestone, light-brown, weathers tan-gray. Slight fine crystalline to micritic. Top of ridge, beds appear massive but a very poor exposure.

Mmc #140: Limestone, very slightly dolomitic, light brown, weathers gray-tan, a pelmicrite. Beds 1 to 2 feet thick. Small calcite veins and spots.

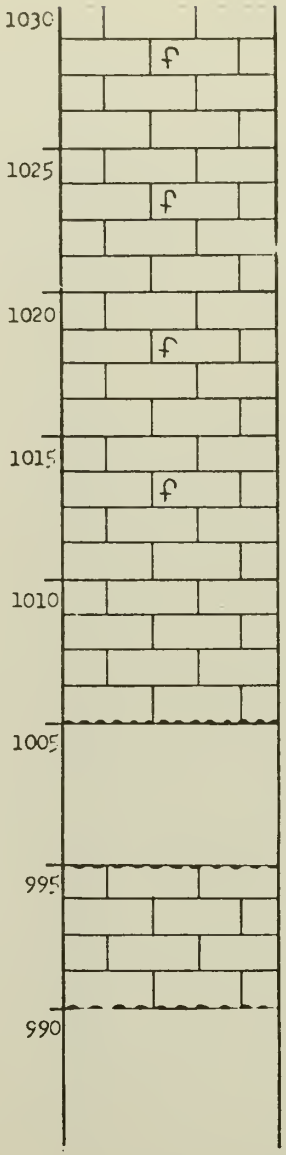
Mmc #139: Limestone, slightly dolomitic, light brown, weathers gray-brown. Pel-micrite. Beds 4-6 feet thick. Very dense in appearance.

Mmc #138: Limestone, light brown, weathers tan-gray. Pel-micrite. Fine pellets. Beds 4 to 6 feet thick. Laminae on weathered surface.

Covered. From 1035 to 1045.

Mmc #136: Limestone, light brown as 134.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 4 of 23)



Mmc #135: Limestone, light brown, as 134.

Mmc #134: Limestone, light brown, weathers gray-brown, biosparite, micritic. Crinoids, brachiopods. Beds 12 inches thick. Laminated appearance on weathered surface.

Mmc #133: Limestone, light brown, weathers gray-brown. Sparry, micritic. Has been sheared and shattered. Rotten rock. Fossils and laminae on weathered surface.

Mmc #132: Limestone, light brown, weathers gray brown. Sparry micrite. Beds 12 inches thick. Crinoids and brachiopod hash. Laterally along outcrop may change to a bio-sparmicrite.

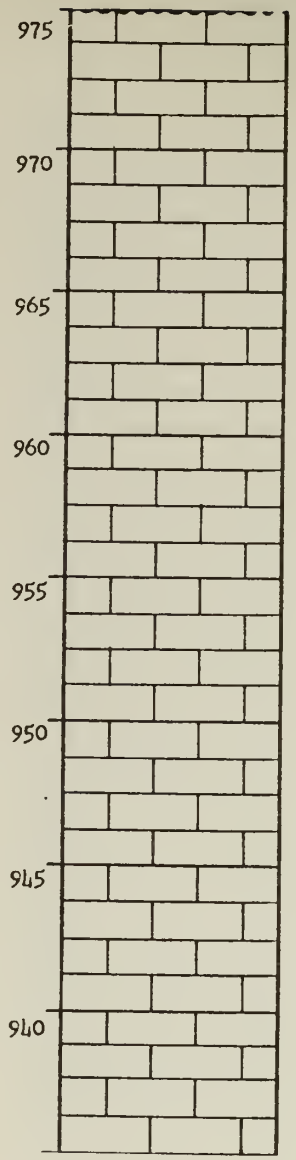
Mmc #131: Limestone, light brown, weathers gray-tan. Sparmicrite. Calcite after fossil debris, probably crinoids. Beds 6-12 inches thick. Poor exposure in junipers.

Covered. From 995 to 1005. 10 feet covered.

Mmc #130: Limestone, very slightly dolomitic. Light brown, weathers gray-brown. Very dense, micritic. Five foot bed outcrops. Laminae on weathered surface. Platy, tough.

Covered from 975 to 990. 15 feet covered.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 5 of 23)



Mmc #129: Limestone, slightly dolomitic, light brown, weathers brown. Very dense, micritic. Hard, tough. Poor exposure.

Mmc #128: Limestone, gray, weathers li ht gray. Dense, micritic, tough. Sheared. Calcite veinlets and blebs. Poorly exposed.

Mmc #127: Limestone, light brown, weathers gray. Dense, micritic. Beds 2 to 3 feet thick. Sheared. Calcite filled veinlets.

Mmc #126: Limestone, dark gray-brown, weathers gray. Very dense, micritic. Sheared. Calcite veinlets. Beds 3 to 4 feet thick. Slight laminae on weathered surface.

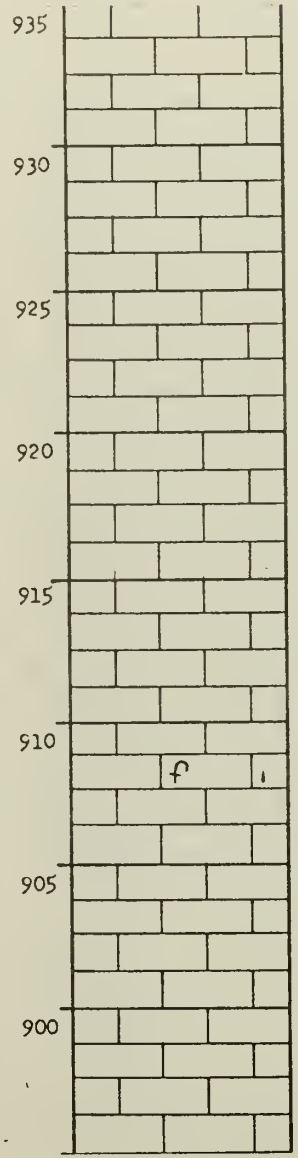
Mmc #125: Limestone, dark gray-brown, weathers gray. Dense, micritic. Algal mat appearance. Beds 3 to 4 feet thick. Sheared.

Mmc #124: Limestone, dark gray-brown, weathers gray. Very dense, micritic. Brecciated, calcite blebs and streaks. Beds 12 to 18 inches thick. Small amount of black-brown chert.

Mmc #123: Limestone, gray to black, weathers gray. Very dense, micritic. Some brecciation, sheared. Poor exposure.

Mmc #122: Limestone, black, weathers gray, Very dense, micritic. Brecciated by solution probably, though not sure. Beds massive, from 6 to 8 feet thick. Black chert nodules. Cliff face, sheared and shattered.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 6 of 23)



Mmc #121: Limestone, gray-black, weathers gray-brown. Very dense, micritic. Massive beds 5 feet thick. Brown chert, cliff exposure. Sheared and shattered outcrop.

Mmc #120: Limestone, light brown-yellow brown, weathers gray. Very fine micritic fragments forming a breccia. Calcite on fractures. Black chert nodules. Dense, lithographic appearing. Massive beds 5 feet thick.

Mmc #119: Limestone, gray-light brown, weathers gray. A solution breccia. Micritic. Few calcite blebs and stringers. Platy bedding. Poor exposure, poor samples.

Mmc #118: Limestone, gray-light brown, weathers gray. A solution breccia. Micrite fragments form breccia. Few fossil fragments. Poor exposures, poor samples.

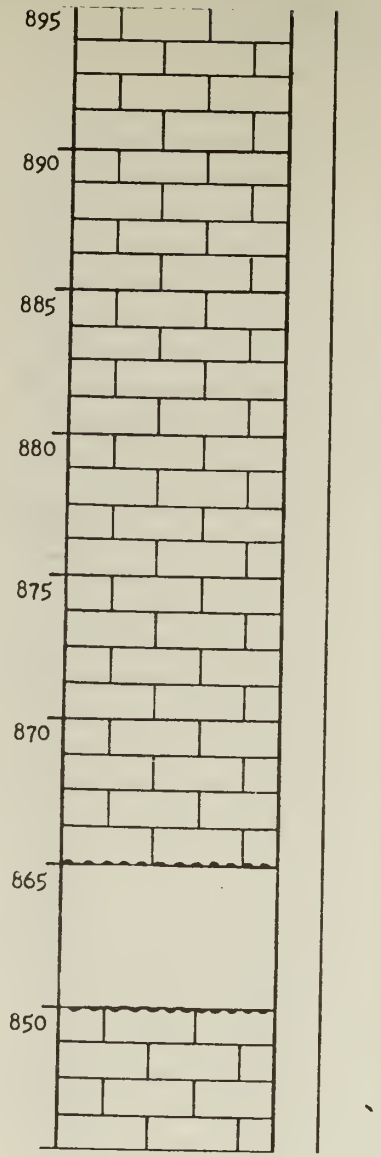
Mmc #117: Dolomite, light brown, weathers gray. Calcite veins banded with gray-brown, light gray and black bands. Appears to be slightly siliceous. Sharp angular fracture pattern. Shattered, deformed looking outcrop.

Mmc #116: Limestone, gray-light brown, weathers light gray. Micrite. Fine crystalline calcite, darker patches of fossil hash. Thin bedded. Fractured. Poorly exposed.

Mmc #115: Limestone, light brown-gray, weathers gray. Micrite. Many small veins of white calcite. Sheared and fractured. Small amount of brown chert.

Mmc #114: Limestone, light brown, weathers gray. Micrite as sample #113.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 7 of 23)



Mmc #113: Limestone, light brown, weathers gray. Very fine to dense, micritic. Hard, tough, fractured, with calcite veinlets. Base of dip slope in bottom of draw.

Mmc #112: Limestone, light brown, weathers gray-tan. Fine crystalline, micritic, but is fractured and probably brecciated. Beds 3 to 6 inches thick. Calcite veinlets. On dip slope.

Mmc #111: Limestone, gray-brown, weathers gray-tan. Fine crystalline to micritic. Fractured. Platy bedding. Dip slope exposure.

Mmc #110: Limestone, light brown, weathers gray-tan. Very fine, crystalline. Few small black specks, probably organic material. 2 inch beds. Fractured, poor exposure.

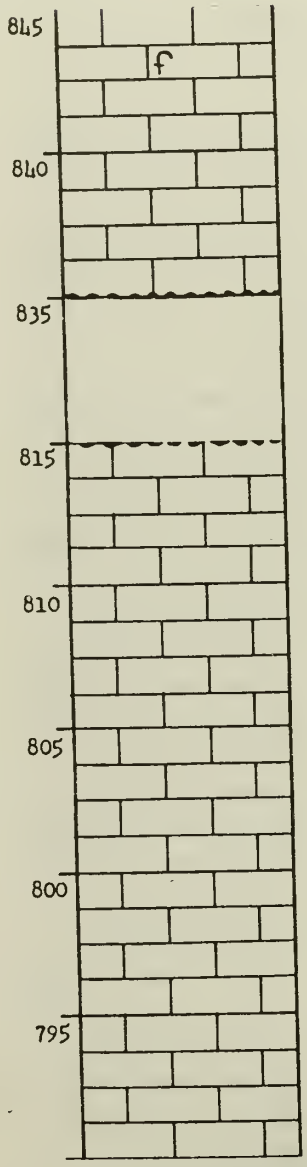
Mmc #109: Limestone, light brown, weathers gray. Very fine crystalline. Very highly fractured, calcite veins.

Mmc #108: Limestone, light gray-brown, weathers tan. A solution breccia, probably originally a micrite. Calcite veinlets. Brown chert stringer. Partially covered. Jointed and fractured.

Covered. From 850 to 865. 15 feet covered.

Mmc #107: Limestone, light brown, weathers tan or light yellow. Jointed and fractured. Calcite veinlets. Fine crystalline. Surface weathers pocked and pitted, laminated.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 8 of 23)



Mmc #106: Limestone, light brown, weathers gray. Fine crystalline. Sparry calcite. Small brachiopods. Laminated on weathered surface. Beds 8 to 12 inches thick. Deeply weathered.

Mmc #105: Limestone, gray-tan, weathers gray to light gray. Calcite fragments, good inter-crystalline porosity. Very badly fractured, weathered, rotten. Sparrite. Almost a calcarenite.

Covered. From 815 to 835. 20 feet covered.

Mmc #104: Limestone, light gray-cream, weathers gray. Micrite with vuggy porosity. Calcite lined vugs. Weathers pocked, laminated. Poor exposure. Beds 12 inches thick.

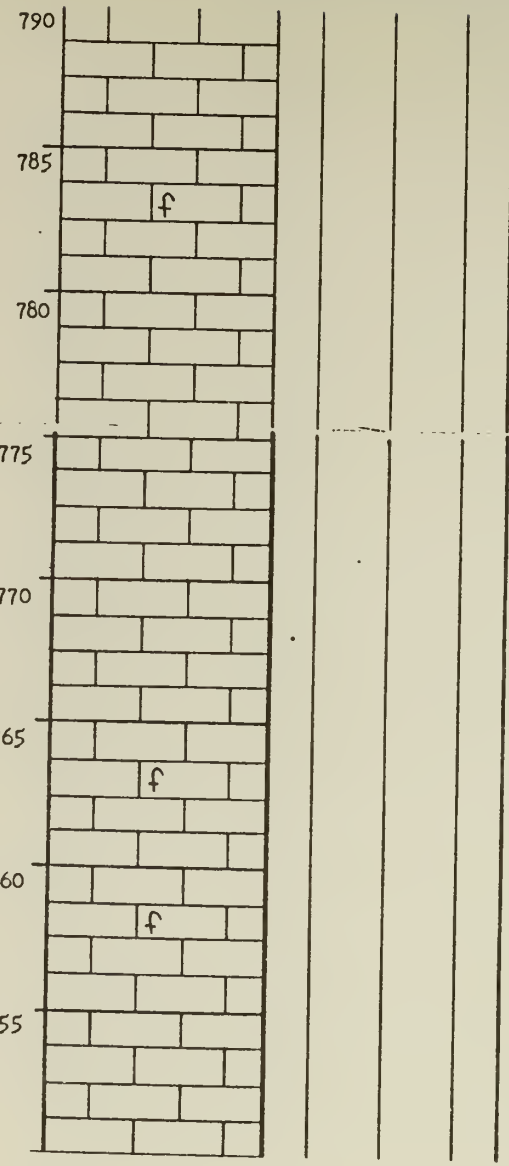
Mmc #103: Limestone, light gray, weathers vreamy-gray. Good small vug porosity. Micrite, dense, even textured. Partially covered.

Mmc #102: Limestone, light brown-gray, weathers tan-gray. Oo-sparite. Weathers pocked, laminated.

Mmc #101: Limestone, light brown, weathers gray-tan. Oo-micrite. Few oolites deformed. Calcite veins. Little sparry calcite after fossils-probably crinoids. Beds 2 feet thick.

Mmc #100: Limestone, gray-brown, weathers gray. Pelletal, micritic, with stray sparry calcite beds. Calcite filled veins. Beds 2 feet thick. Like # 99/

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 9 of 23)



Mmc # 99: Limestone, gray-brown, weathers tan-gray. Good pelletal texture with sparry calcite after crinoids. Beds 2 feet thick. Laminated on weathered surfaces.

Mmc #98: Limestone, gray-brown, weathers gray, sparry calcite with poorly defined pellets. Small crinoid fragments. Locally a bio-sparite. Slightly arenaceous appearing on weathered surface. Beds 2 feet thick.

Mmc #97: Limestone, light gray-brown, weathers light gray. Good sparry calcite, medium crystalline. Beds 2 feet thick. Appears argillaceous. Poor exposure on ridge top.

Mmc #96: Limestone, gray-brown, weathers tan-gray. Medium crystalline, sparite. Fractured. Calcite filled veins. Beds 2 feet thick. Slightly pelletal. Poor exposure near ridge top.

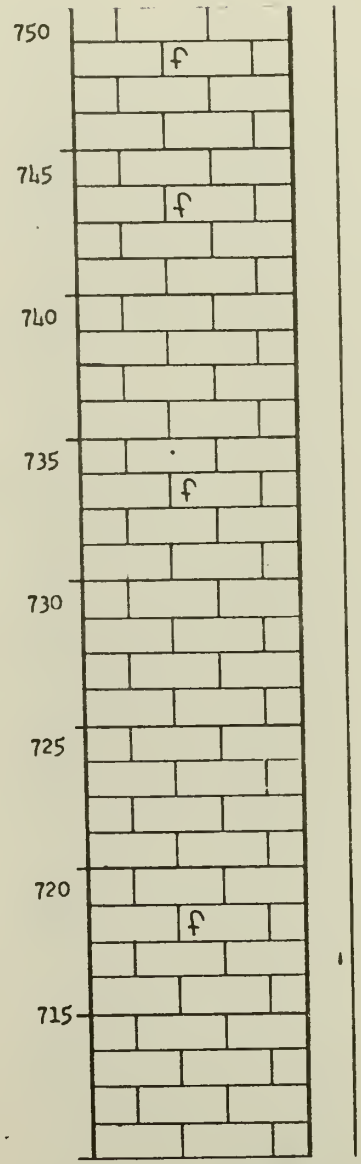
Mmc #95: Limestone, gray-brown, weathers gray-tan. Medium grain, crystalline calcite. Algal. Weathers pocked, slightly laminated. Vertical fractures filled with hair line thin calcite veins. Beds 2 to 4 feet thick.

Mmc #94: Limestone, gray-brown, weathers gray-tan. Sparry with micritic matrix. Appears to have rudimentary pellets. Massive beds. Fractured. Calcite filled veins. Algal looking in places. Fossil debris.

Mmc #93: Limestone, gray-brown, weathers gray-tan. Pelsparite. Fractured with abundant sparry calcite. Weathers pocked, laminated. Massive beds, 4 to 6 feet thick. Occasional fossils.

Mmc #92: Limestone, gray-brown, weathers gray. A bio-pelsparite. Massive beds, 4 to 6 feet thick. Cross laminae on weathered surface. Crumbly when struck with hammer.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 10 of 23)



Mmc #91: Limestone, gray, weathers light gray. Excellent pelletal texture, in micritic matrix. Brachiopods, corals, crinoids. Thick beds up to 4 feet thick. Pocked, laminated on weathered surface. Appears cross laminated.

Mmc #90: Limestone, gray-brown, weathers light gray-tan to white. Pelletal, bio-sparite, medium to coarse crystalline. Fractured, few fossils. Pocked surface when weathered. Beds 3 to 4 feet thick.

Mmc #89: Limestone, gray-brown, weathers light gray-tan. Sparitein micrite and fine pelletal matrix. Bio-sparite after crinoids in places. Beds are 3 to 4 feet thick. Hard to get good samples. Exfoliates on weathered surface.

Mmc #88: Limestone, gray-brown, weathers gray-tan. Bio-pel-sparite. Medium to coarse crystalline calcite. Good small pellets. Beds 12 inches thick. Crinoids and corals. Cliff former. Dip 32° NW, Strike 39° E.

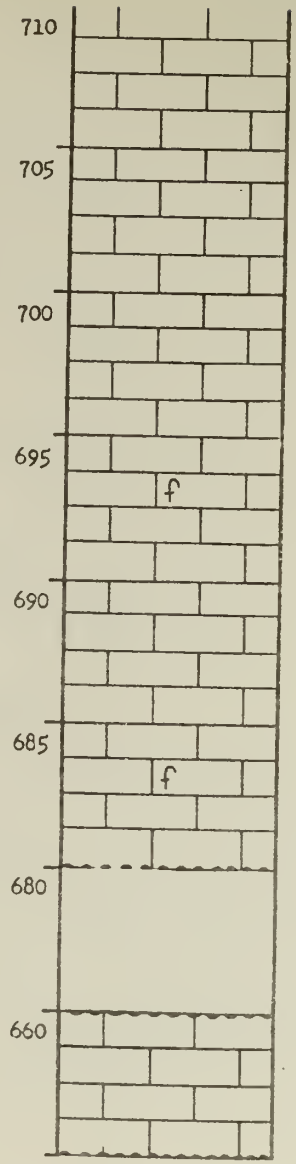
Mlp Covered. Top of Ledgepole. Mission Canyon above. Changes to very massive beds. Slight color change. Lighter gray is Mission Canyon.

Mlp #87: Limestone, gray-light gray, weathers gray. Bio-sparite micritic. Largely covered slope.

Mlp #86: Limestone, gray, weathers gray-brown. Micrite with scattered calcite crystals after fossils. Crinoid and brachiopod fragments. Bio-spar-micrite. Poor exposure.

Mlp #85: Limestone, gray-brown, weathers gray-tan. Micrite to fine crystalline. Rusty brown film on weathered surface. Occasional calcite after fossils. Thin bedded, 4 to 6 inches. Much like #84.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 11 of 23)



Mlp #84: Limestone, gray with red spots, weathers gray-tan. Micrite. Blocky fracture. Tough. Poor exposure.

Mlp #83: Limestone, gray, weathers gray-tan. Micrite and pel-micrite beds. Small amount of calcite after fossils. Blocky fracture.

Mlp #82: Limestone, gray, weathers gray-tan. Same as #81.

Mlp #81: Limestone, gray, weathers gray-tan. Micrite. Very angular fracture pattern. Appears thin-bedded when weathered. Few brachiopods. Beds 4-6 inches thick.

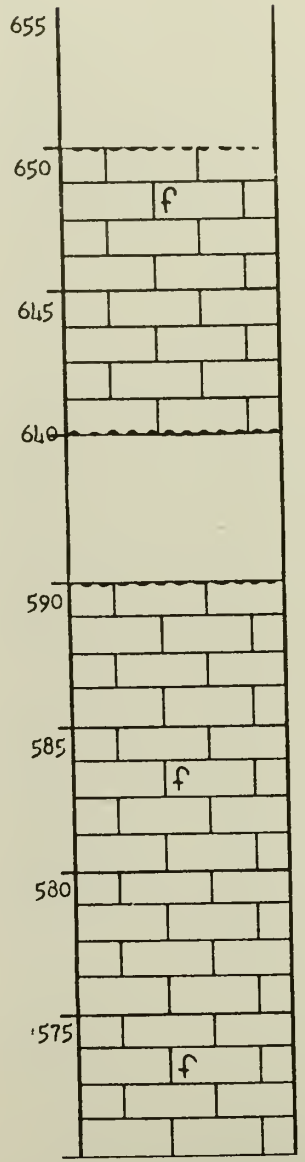
Mlp #80: Limestone, gray, weathers gray-tan. Dense, micritic. Massive beds, 4 feet thick. Weathers pocked and laminated with a brown silty ribbing. Light brown chert nodules.

Mlp #79: Limestone, gray, weathers gray-tan. Bio-spar-micrite. Crinoid and brachiopod fragments. Beds 2 to 8 inches thick. Few specks red iron stain. Calcite replaces fossils.

Covered. From 660 to 680. 20 feet covered.

Mlp #78: Limestone, gray to dark gray, weathers gray. Dense, micritic. Brownish algal structures. Fractured. Calcite filled veins. Beds 4 to 6 inches thick. Pocked weathering.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 12 of 23)



Covered. 5 feet covered.

Mlp #77: Limestone, dark gray-brown, weathers gray-tan. Micritic. Blocky, sharp angular fracture. Tough. Few fossils. Beds 2 to 6 inches thick.

Mlp #76: Limestone, dark gray, weathers gray-tan. Micritic. Beds 4 inches thick. Very hard, dense. Tough.

Covered. From 591 to 640. 49 feet covered.

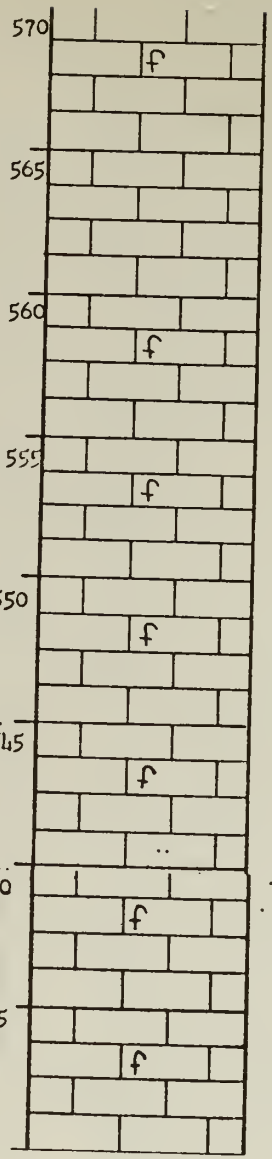
Mlp #75: Limestone like #73 and 74.

Mlp #74: Limestone, gray, weathers gray. Micrite, very dense. Few brachiopods. Thin beds 2 to 4 inches thick.

Mlp #73: Limestone, gray, weathers gray. Fine, dense, micrite. Fractured. Thin beds, 2 to 4 inches thick. Poor exposure.

Mlp #72: Limestone, gray-brown, weathers tan-gray. Dense to sparry crystalline. Fractured. Calcite veins. Slightly fossiliferous. Fossils show on weathered surfaces. Poorly exposed.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 13 of 23)



Mlp #71: Limestone, gray-brown, weathers tan-gray. Bio-sparite, to dense micritic. Medium to coarse crystalline. Calcite. Fossil hash after brachiopods, crinoids, and corals. Fractured.

Mlp #70: Limestone, gray-graybrown, weathers tan-gray. Bio-sparite to micritic. Very poor exposure. Weathers into platy fragments. Flaggy. Beds 2 to 10 inches thick. Similar to #68.

Mlp #69: Same as #68.

Mlp #68: Limestone, gray-brown, weathers gray-tan. Bio-sparite. Platy bedding, very fossiliferous. Poor exposure. Fossil hash. Crystalline calcite, coarse to medium xtln.

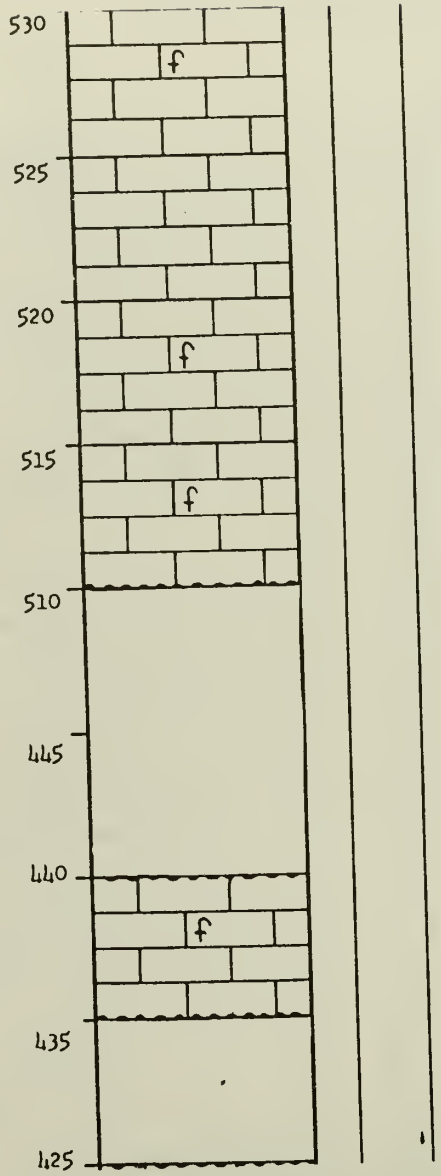
Mlp #67: Limestone, gray-light brown, weathers gray-tan. Bio-sparite. Fossil hash. Coarse to medium crystalline calcite. Beds 4 to 6 inches thick. Good brachiopod fossils. Abundant pellets.

Mlp #66: Limestone, gray-brown, weathers gray-tan. Bio-sparite, medium crystalline. Crinoid and other fossil debris. Beds 6 to 8 inches thick. Calcite veins. Fractured. Weathers pocked. Lots of pelletal material, few oolites. Limonite staining.

Mlp #65: Limestone, gray, weathers gray-tan. Bio-sparite, oolitic, deformed oolites, limonite on fractures, calcite veins. Fosil brachiopods, crinoids and coral. Fossil hash in places. Beds 6 to 8 inches thick. Weathers pocked.

Mlp #64: Limestone, gray-brown, weathers gray-tan. Oolites, pellets, bio-sparite. Fosil corals, crinoids, and brachiopods. Beds 4 to 8 inches thick. Weathers pocked, fractured. Calcite veinlets, slight limonite staining. Strike N 41° E. Dip 46° NW.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 14 of 23)



Mlp #63: Limestone, gray-brown, weathers gray-tan. Oolites, sparite, deformed oolites, and pellets. Sparry calcite after fossils. Crinoid hash. Beds 4 to 12 inches thick. Weathers pocked. Slight limonite stain.

Mlp #62: Limestone, gray-brown, weathers gray-tan. Oolites, sparite, good oolites, deformed oolotes and pellets. Sparry calcite after fossils. Beds 4 to 12 inches thick. Weathers pocked.

Mlp #61: Limestone, gray to light brown, weathers gray-tan. Mottled. Bio-sparite. Limonite stained pellets. Beds 4-12 inches thick. Weathers pocked. fossil debris.

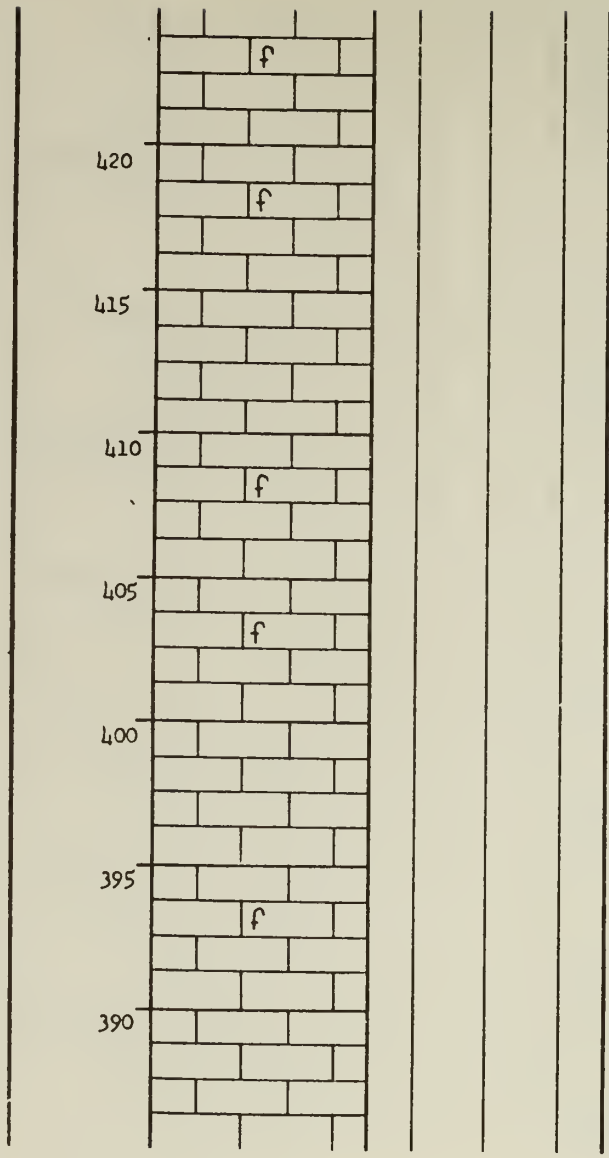
Mlp #60: Limestone, light gray to gray, weathers gray-brown, mottled. Bio-pel-sparite, fine to medium crystalline. Gray to yellow-brown banding and mottling on weathered surface. fossil debris. Beds 1 to 10 inches thick.

Covered. Covered from 442 feet to 510 feet. 68 feet covered.

Mlp. #59: Limestone, light gray, weatners gray-brown, Bio-sparite, platy bedding. Beds 2 to 4 inches thick. Good brachiopods, crinoid hash. Incipient pellets. Poor exposure.

Covered. From 427 feet to 437 feet. 10 feet covered.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 15 of 23)



Mlp #58: Limestone, gray to dark gray, weathers gray-brown. Bio-pel-micrite. Crinoids and brachiopods. Incipient pellets.

Mlp #57: Limestone, partially covered, dark gray, weathers gray brown. Micritic to very dense. 6 foot bed. Pel-micrite. Sparry calcite. Weathers laminated. Brachiopods, crinoids.

Mlp #56: Limestone, partially covered, dark gray, weathers gray brown. Micrite.

Mlp #55: Limestone, dark gray, weathers gray-brown. Sparry micrite with calcite blebs after fossils. A bio-spar-micrite. Beds 8 to 12 inches thick. Weathers pocked. Tough, dense rock.

Mlp #54: Limestone, dark gray, weathers gray-brown, micrite. Beds 2 to 4 inches thick, platy, fractured, laminated on weathered surface. Occasional fossil fragments.

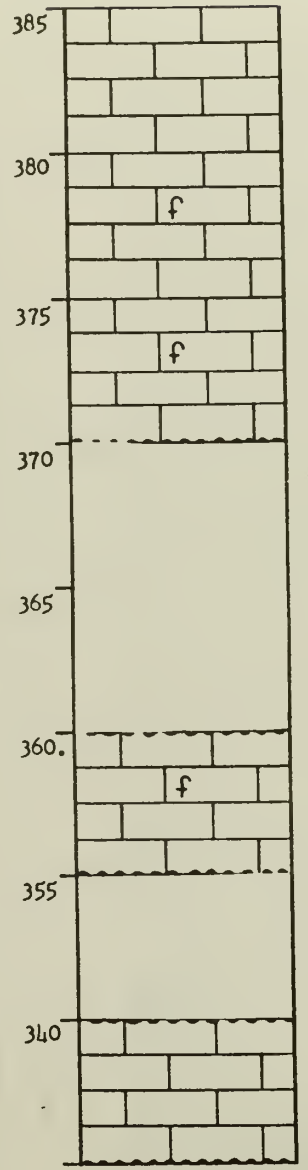
Mlp #53: Limestone, dark gray, weathers gray-brown. Micrite. Beds 2 to 4 inches thick. Platy, fractured, laminated on weathered surface. Occasional fossil fragments.

Mlp #52: Limestone, dark gray, weathers gray-tan. Fine crystalline to micritic. Few calcite filled veins. Beds 4 to 8 inches thick. Fractured.

Mlp #51: Limestone, gray, weathers rusty gray. Fine crystalline, micritic. Beds 8 to 12 inches thick. Few fossils. Calcite vein fillings. Poor exposure on ridge crest.

Mlp #50: Limestone, gray-light brown, weathers rusty gray-tan. Fine crystalline to micritic, dense. Beds 2 to 4 inches thick. Little brown chert, few fossils. Poor exposure.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 16 of 23)



Mlp #49: Limestone, gray-brown, weathers rusty brown, brown chert. Sparry micrite. Beds 4 to 8 inches thick. Fractured, very pocked on weathered surface. Poor exposure.

Mlp #48: Limestone, gray-brown, weathers gray-tan, Very fine crystalline to micritic. Fossiliferous. Brown chert nodules. Calcite veinlets. Blocky fracture. Beds 8 to 12 inches thick.

Mlp #47: Limestone, gray-brown, weathers gray-tan. Fine crystalline. Sparry calcite. Calcite veinlets. Weathers pocked. Fractured. Few fossils, fetid odor when broken. Beds 6 to 12 inches thick.

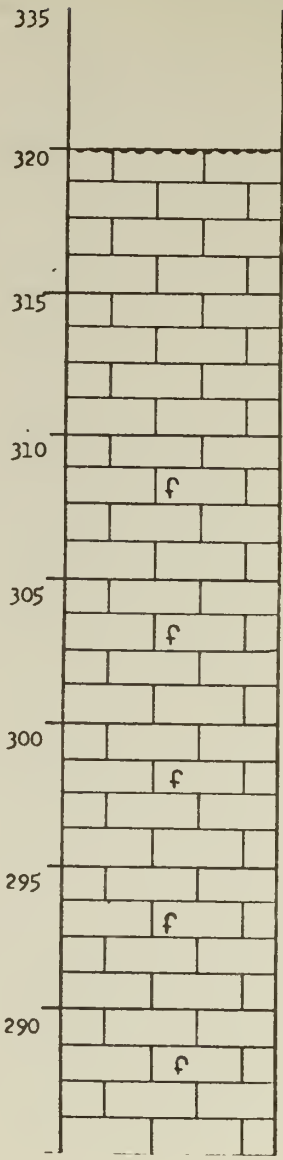
Covered. From 362 to 369. 7 feet covered.

Mlp #46: Limestone, light gray-brown, weathers tan-brown. Bio-sparite to fine to medium crystalline. Abundant fossils-brachiopods, crinoid hash. Poor exposure. Rock breaks and crumbles easily.

Covered. From 339 to 356. 17 feet covered.

Mlp #45: Limestone, dark fray to gray-brown, weathers brown. Micrite with few spots of sparry, medium, crystalline calcite. Few calcite lined vugs. Beds 6 to 9 inches thick. Good blocky fracture, poor exposure.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 17 of 23)



Strike N 31° E, Dip 34°.

Covered. From320 feet to 334 feet. 14 feet covered.

Mlp #44: Limestone, gray, weathers gray- light brown. Locally very fractured. Calcite along fractures. Brown chert. beds 8 to 12 inches thick. Poor exposure to top of cliff. Varies from micritic to fine crystalline.

Mlp #43: Limestone, gray, weathers light gray. Locally sparry calcite after fossils. Brown chert. Beds 8 to 12 inches thick. Laminae show on weathered surface. Top of cliff sequence.

Mlp #42: Limestone, gray, weathers light gray. Fine, sparry micrite, with sparry fossil hash. Looks massive but laminae on weathered surface. Crinoids. Lots of brown chert. Beds 8 to 12 inches thick.

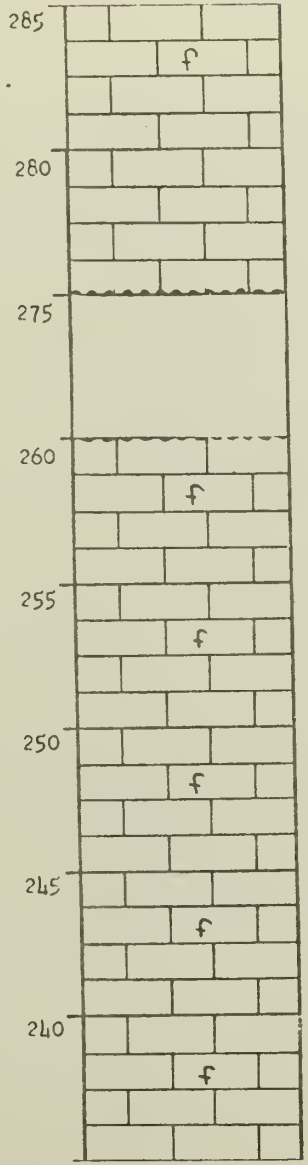
Mlp #41: Limestone, gray, weathers gray-light-brown, fine sparry micrite. Fractured. Vertical seams of calcite. Stringers of brown chert. Beds 8 to 12 inches thick. Fossiliferous.

Mlp #40: Limestone, dark gray-brown, weathers light gray-tan. Micritic to very fine crystalline. Some places fine to medium bio-sparite. Fossiliferous. Calcite veins, and seams. Brown chert. beds 6 to 8 inches thick.

Mlp #39: Limestone, gray-brown, weathers light gray-tan. Micritic to very fine crystalline. Little sparry calcite. Beds 6 to 8 inches thick. Hard, tough. Very fossiliferous. Weathered hash of fossils.

Mlp #38: Limestone, gray, weathers light gray-tan. Fine bio-micrite to sparry micrite. Beds 4 to 6 inches thick. Hard, toug on surface. Cliff former. Crinoids, brachiopods and otner fossil hash.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 18 of 23)



Mlp #37: Limestone, dark gray, weathers tan-gray. Fine bio-micrite, slightly sparry, fossiliferous, appears massive but beds3 to 6 inches thick. Yellow-brown silty partings. Tough. Pocked weathering.

Mlp #36: Limestone, gray-brown, weathers gray. Bio-spar-micrite. Slightly pelletal. 2 to 3 inch thick beds. Silty brown partings 1/4 to 1/2 inch thick. Very steep cliff, 20 feet high. Weathers pocked.

Covered. From 260 feet to 275 feet covered. 15 feet covered.

Mlp #35: Limestone, light gray-tan, to yellow-brown. Limonite stains. Appears to be a solution breccia in part. Zones of bio-sparite. Argillaceous appearing on weathered surface. Fossiliferous. Weathers crumbly. Poor exposure.

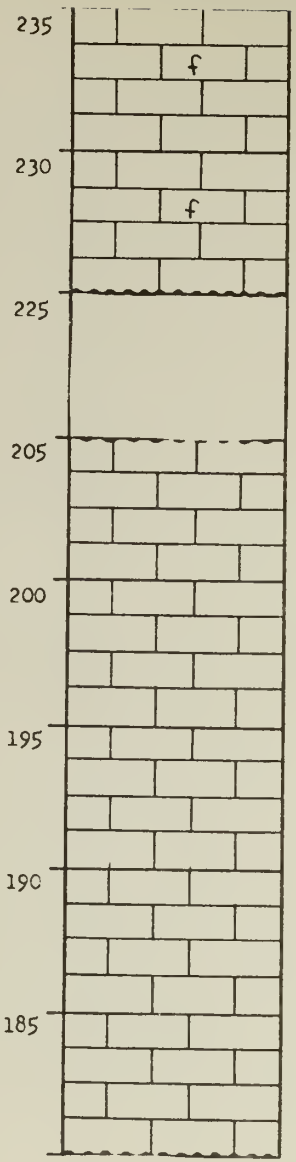
Mlp #34: Limestone, gray-light brown, weathers tan-gray. Some areas medium crystalline sparite. Others fine crystalline to bio-micrite. Few fossils. Beds 2 to 4 inches thick. Poor exposure.

Mlp #33: Limestone, light brown-gray, weathers gray. Bio-spar-micrite to sparite. Few areas medium crystalline. Fossil brachiopods and crinoids. Hard, tough. Beds 2 to 6 inches thick. Sharp, angular when broken.

Mlp #32: Limestone, gray-brown, weathers gray-tan. Pel-micrite. Weathers slightly laminated. Pocked on surface. Crinoids, brachiopods, and echinoid spines. Talus very fossiliferous. Locally a bio-sparite. Poor exposure.

Mlp #31: Limestone, dark gray-tan, weathers tan. Fine crystalline, sparry grains. Beds 1 to 3 inches thick. Weathers pocked. Very fossiliferous, bryozoa, corals, crinoids, and brachiopods. Bio-sparite. Thin platy bedding. Fractured.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 19 of 23)



Mlp #30: Limestone, dark gray-tan, weathers gray-tan. Very fine micritic. Fossiliferous-crinoids, brachiopods, rugose corals, and hash. Weathers slightly pocked on surface. Thin beds, 3 to 4 inches thick. Argillaceous bands.

Mlp #29: Limestone, gray to light brown, weathers gray. Very fine micritic. Locally pelletal, small blebs of sparry calcite. Beds 2 to 4 inches thick. Crinoid fragments. Weathers slightly pocked. Platy, fractures into sharp, angular fragments.

Covered. From 205 to 225. 20 feet cove red.

Mlp #28: Limestone, dark gray, weathers gray-tan. Very fine micritic. Conchoidal fracture. Brwon chert in float. Thin bedded.

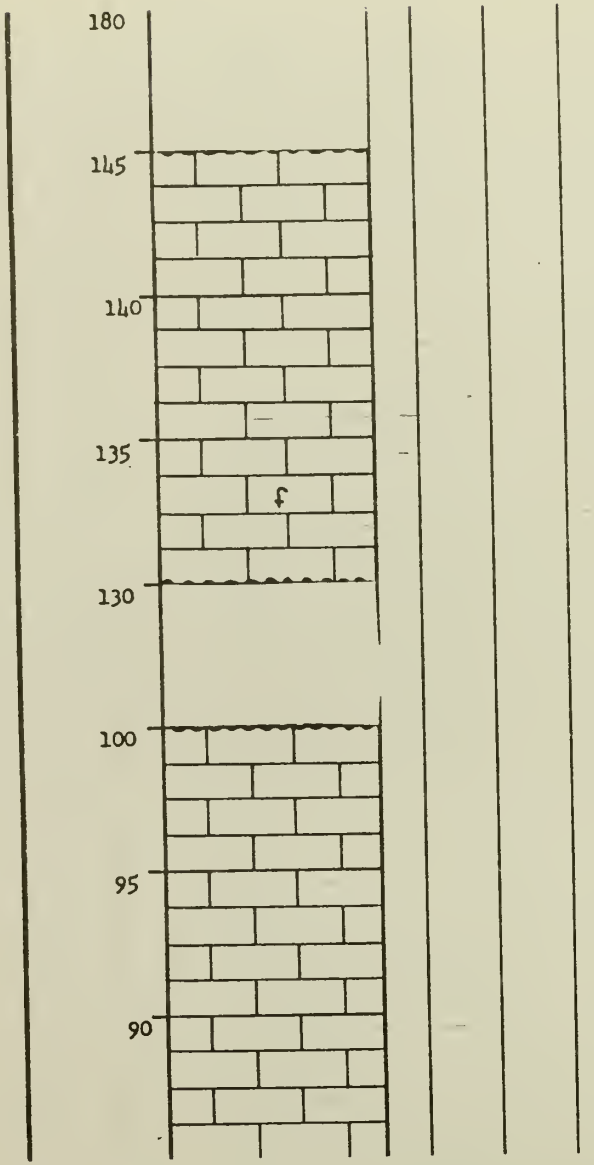
Mlp #27: Limestone, dark gray-brown, weathers gray with rusty spots. Very fine micritic, with pelletal material in some beds. Brown chert in float. Conchoidal fracture. Thin-bedded. Poor exposure.

Mlp #26: Limestone, dark gray-brown, weathers gray-tan. Very finemicritic. Fractured. Beds 2 to 6 inches thick. Like #25.

Mlp #25: Limestone, dark gray-brown, weathers gray-tan. Dense to micritic. Brown chert in float. Beds 2 to 6 inches thick. Fractured. Poor outcrop.

Mlp #24: Limestone, dark gray-brown. Very fine micritic or dense. Weathers gray-brown. Laminae on weathered surface. Poor exposure.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 20 of 23)



Covered. From 145 feet to 180. 35 feet covered.

Float indicates thin-bedded dark-gray limestone.

Mlp #23: Limestone, dark gray-black, weathers gray. Very fine to micritic. Platy to thin bedded. Laminated on weathered surface. Pocked surface when weathered. Beds 6 to 8 inches thick. Fractured.

Mlp #22: Limestone, gray-brown, weathers gray-tan. Dense to very fine grain. Weathered surface shows laminae. Few thin shaly partings. Calcite veinlets. Beds 6 to 12 inches thick.

Mlp #21: limestone, light gray-brown, weathers gray. Oolitic or pelletal, sparry calcite, fossiliferous. Crinoids, brachiopods, spicules. Laminated and crenulated on weathered surface. Beds 2 to 14 inches thick.

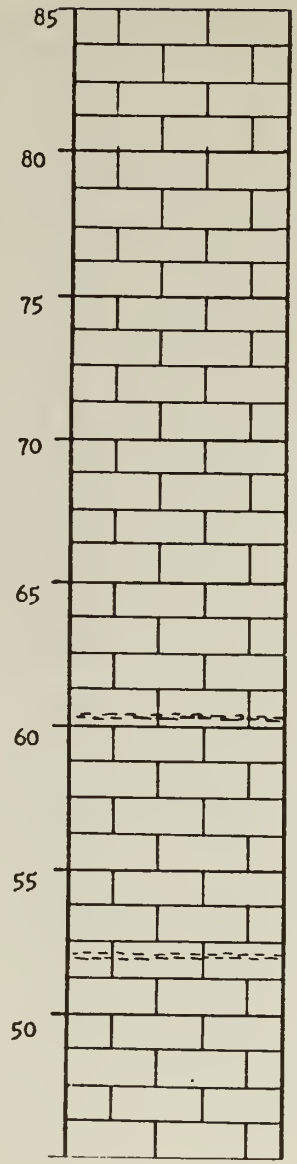
Covered. From 100 feet to 130 feet. 30 feet covered.

Mlp #20: Limestone, dark gray, weathers light gray. Very dense, micritic. Laminae on weathered surface. Fractures filled with sparry calcite. Platy bedding 1/4 to 1/2 inches thick.

Mlp #19: Limestone, dark gray, weathers gray. Very fine dense, micritic. Argillaceous. Weathers and pocked and laminated with small crenulations. Partially covered slope.

Mlp #18: Limestone, light brown to black, weathers brown to dark gray. Very fine crystalline to dense, micritic. Beds vary from thin plates to 12 inches thick.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 21 of 23)



Mlp #17: Limestone, light brown to black, weathers dark gray. Very fine crystalline to dense, micritic. Beds vary from platy to 12 inches thick. Shows some micro-crystalline texture.

Mlp #16: Moved 300 meters Sw to better outcrop. Limestone, dark gray, weathers gray to slightly tan-gray. Very dense, argillaceous. Thin to platy bedding, laminae on weathered surface. Pocked on weathered surface. Slightly rusty, streaked.

Mlp #15: Limestone, dark gray-black, weathers dark gray-gray. Very dense, micritic. Platy bedding from 1/4 inch to 12 inches. Weathers pocked, laminated, crenulated laminae.

Mlp #14: Limestone, dark gray-black, weathers gray- dark gray. Very fine, dense. Bedding varies from platy to 12 inches thick. Fractured. Few calcite veinlets. Occasional thin yellow brown clay silt layers or partings.

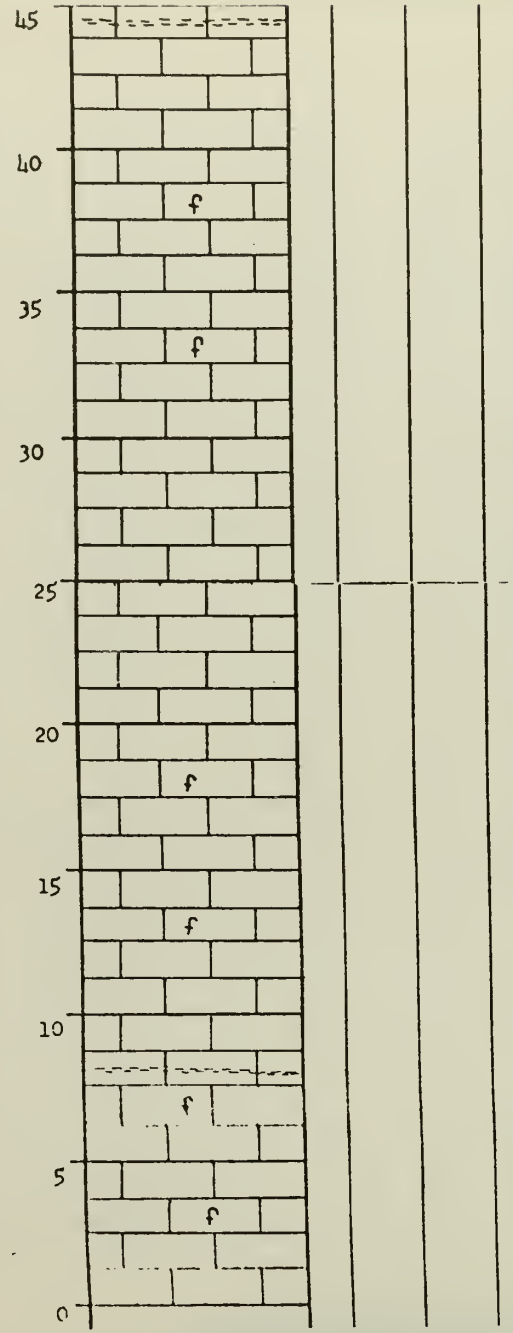
Mlp #13: Limestone, dark gray-black, weathers gray. Very fine crystalline to dense. Fractured, platy bedding. 2 inch clay layer at base. Calcite veinlets. Rusty brown streaks. Weathers pocked. Beds 4 inches to 12 inches thick.

Mlp #12: Limestone, dark gray, mottled light yellow cream, weathers gray. Very fine grain to dense. Platy on weathered surface. Small calcite veins. Crenulated laminae. Beds 4 to 12 inches thick.

Mlp #11: Limestone, dark gray, weathers gray. Dense, argillaceous. Thin seams of gray-brown shale. Possibly mudstone. Weathers pocked, platy. Possible worm trails.

Mlp #10: Limestone, dark gray to black, weathers gray. Very dense. Fine laminae. Fractured, calcite along fractures. Appears platy. Beds 4 to 8 inches thick.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 22 of 23)



Mlp #9: Limestone, black, weathers gray. Very fine grained dense. Fractured. Appears laminated on weathered surface. Top 3 inches brown-yellow silty clay. Beds 6 to 9 inches thick.

Mlp #8: Limestone, black, weathers gray. Very dense. Highly fractured. Fine fossiliferous hash shows on weathered surface. Beds 6 to 8 inches thick.

Mlp #7: Limestone, black, weathers gray. Very dense. Fractured. Weathers slightly pitted and pocked. Fossils are scattered. Beds 6 to 8 inches thick.

Mlp #6: Limestone, gray-black, weathers gray. Few sparry calcite blebs. Very much fractured. Fine grain to dense. Beds 3 to 9 inches thick.

Mlp #5: Limestone, dark gray-black, weatners gray. Very fine to dense. Small sparry calcite blebs after crinoids. Weathers slightly pitted. Beds are 3 to 9 inches thick.

Mlp #4: Limestone, dark gray to black-brown, weathers gray. Very slightly dolomitic. Very fine to dense. Fractured into ½ inch blocks. Few fractures with calcite filling openings. Beds 2 to 4 inches thick. Pitted, pocked on weathered surface. Small amount of fossil hash. Brown chert. Poor preservation of fossils.

Mlp #3: Limestone, gray-black, weathers gray to tan. Very fine micritic. Weathers with pitted surface. Rugose corals, crinoid fragments, few brachiopods. Beds 4 to 10 inches thick. Steep slope. At 14 feet is a 6 inch bed of fossil hash.

Mlp #2: Limestone, gray, weathers gray-tan. Medium crystallin Sparry calcite. Crinoid fragments. Rugose coral. 3 to 4 inch thick bed of shaly, yellow-brown clay at 9 feet 6 inches Beds 6 to 12 inches thick. Fossil hash. Brown chert nodules.

Mlp #1: Limestone, gray, weathers light gray. Fine micritic, few scattered calcite specks. Crinoid columnals. Brown chert nodules up 6 inches across. Fractures filled with calcite. Appears to be slightly oolitic or pelletal. Beds 4 to 12 inches thick.

MADISON GROUP SECTION, LOGAN, MONTANA (Sheet 23 of 23)

APPENDIX B

BIBLIOGRAPHY OF CARBONATE ROCKS

This bibliography of source material related to carbonate rocks is cited in Subsection 5.2 in Book 1 of this volume.

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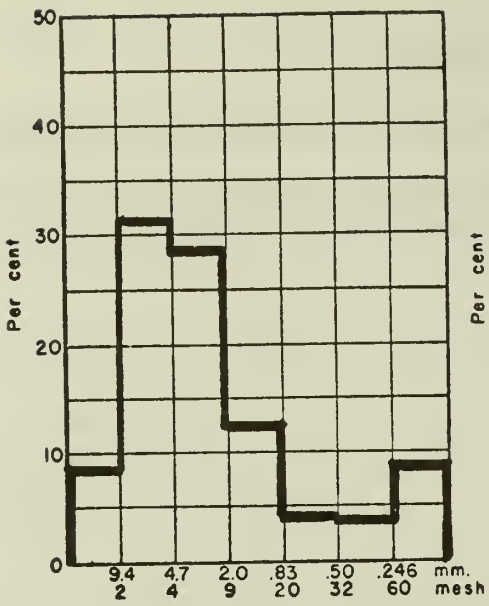
APPENDIX C

HISTOGRAMS FROM DROP HAMMER TESTS ON CARBONATE ROCKS

The histograms presented in this appendix record experimental data from the drop hammer tests described in Subsection 5.2 of Book 1 of this volume.



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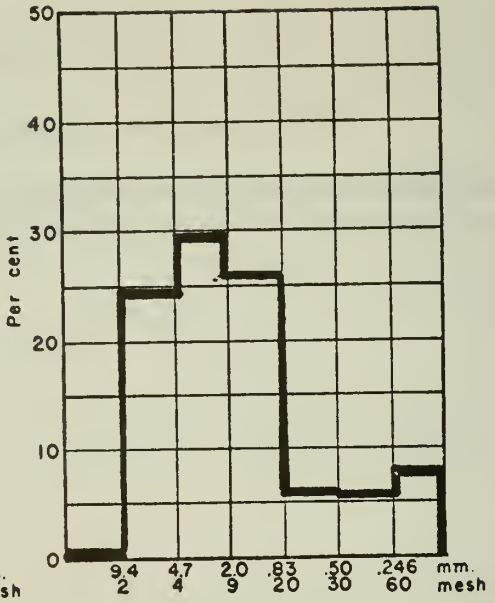

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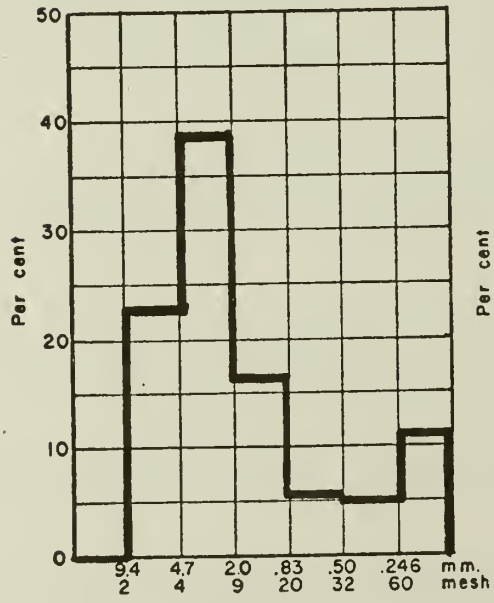

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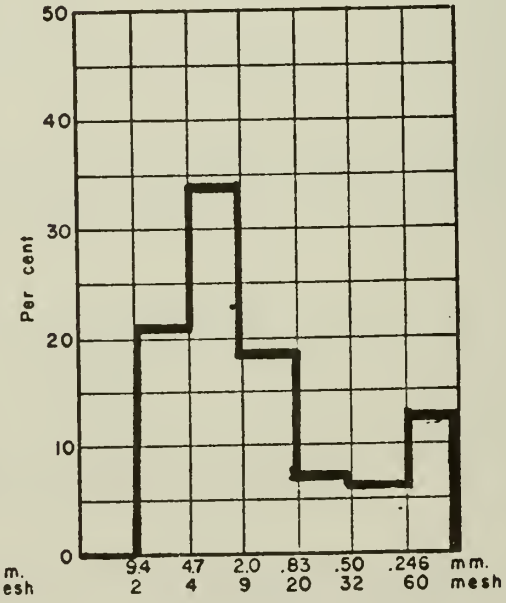

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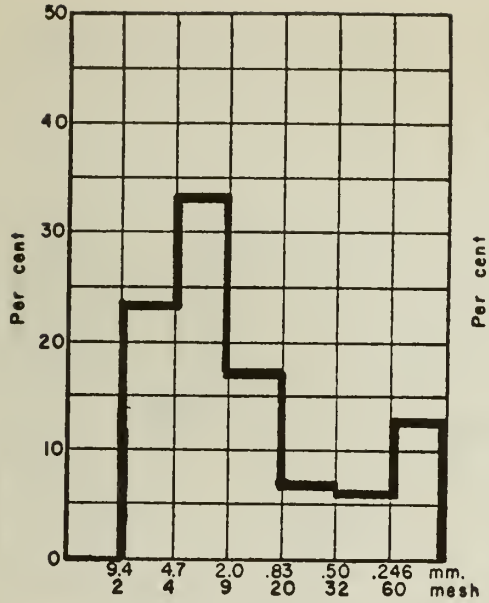

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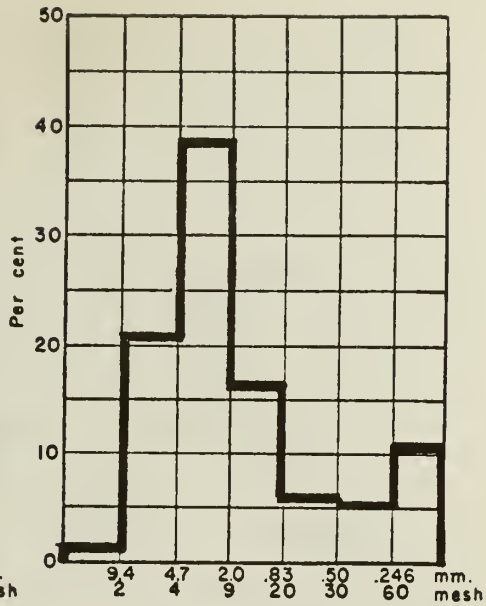

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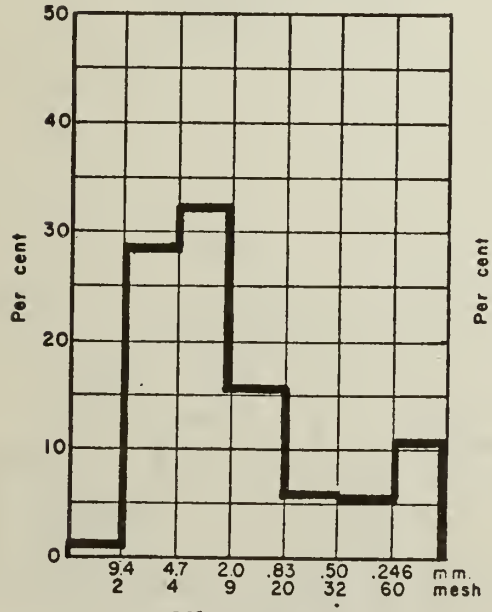

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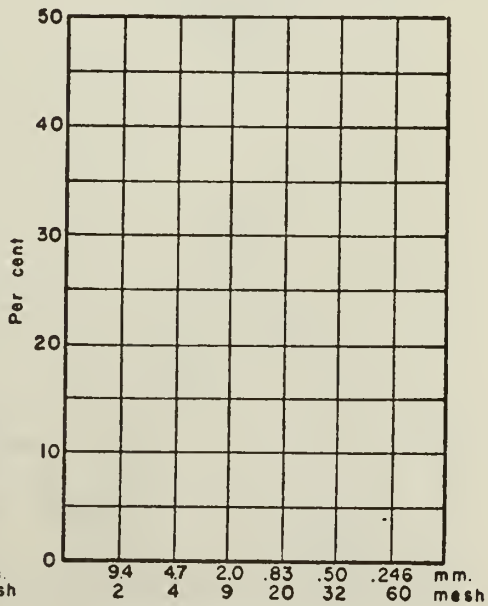

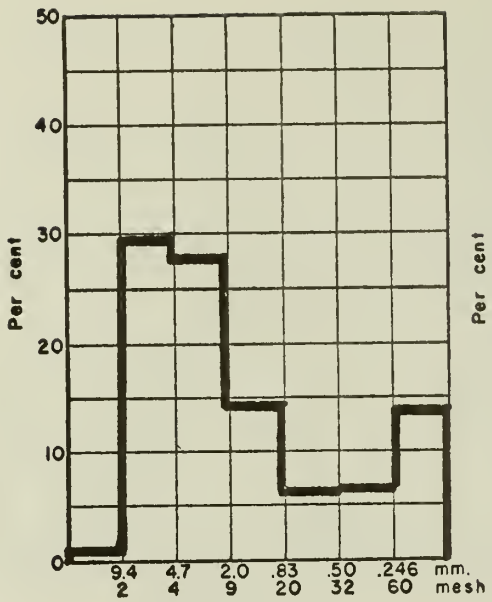

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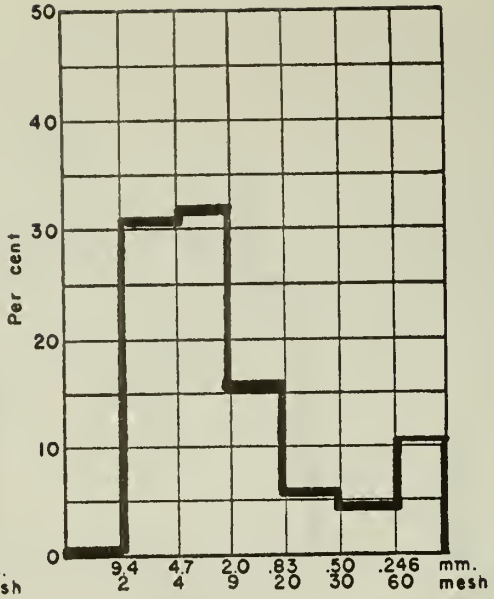

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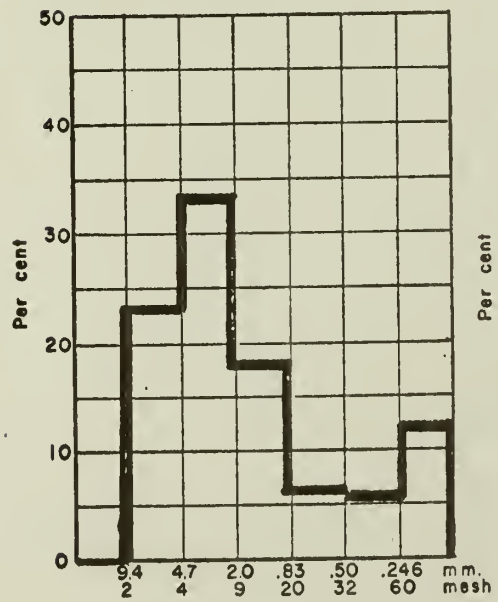

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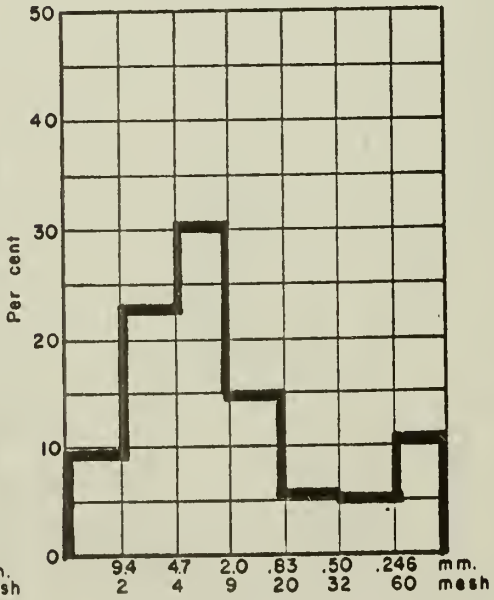

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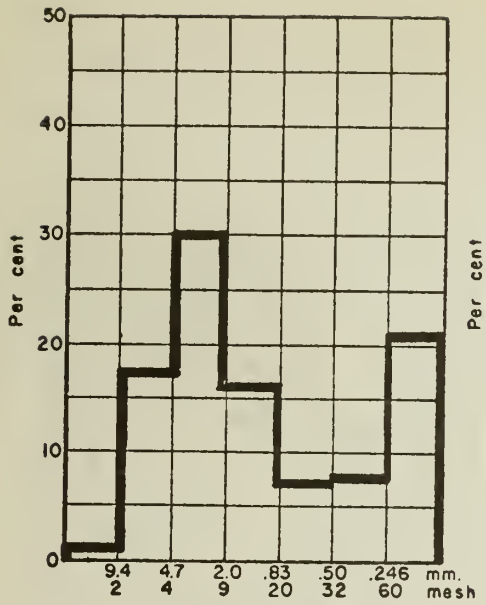

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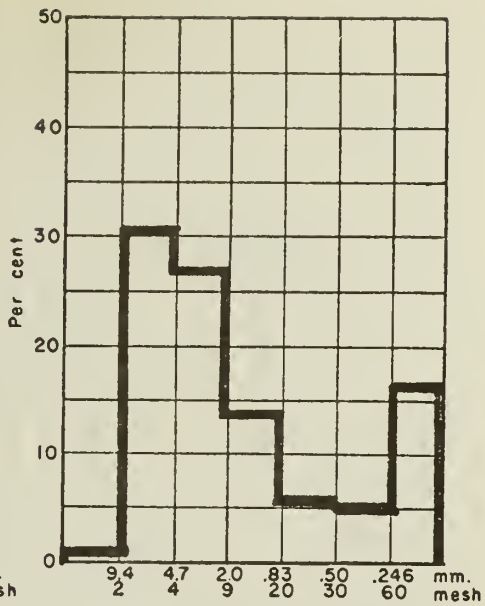

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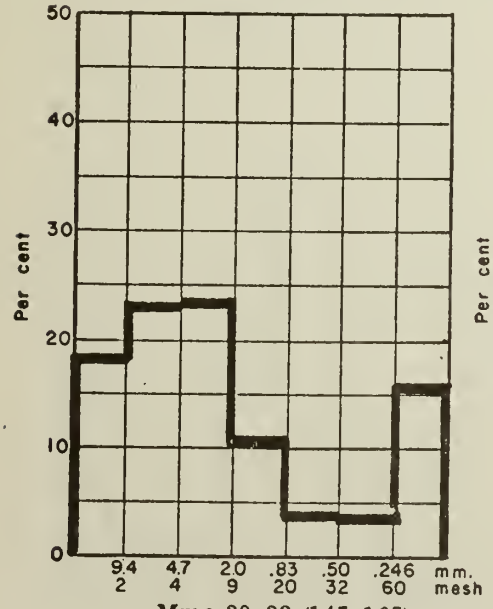

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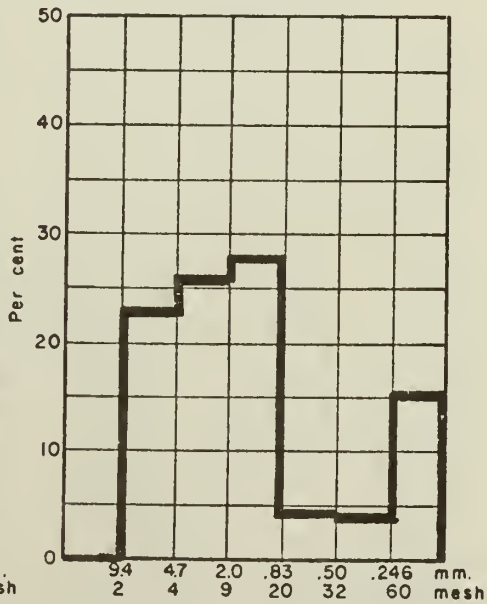

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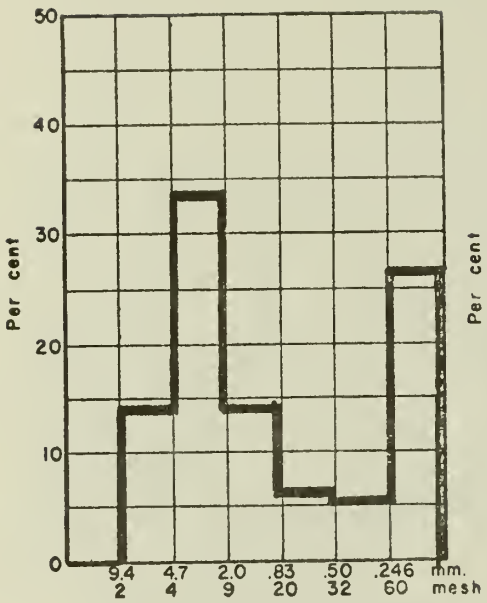

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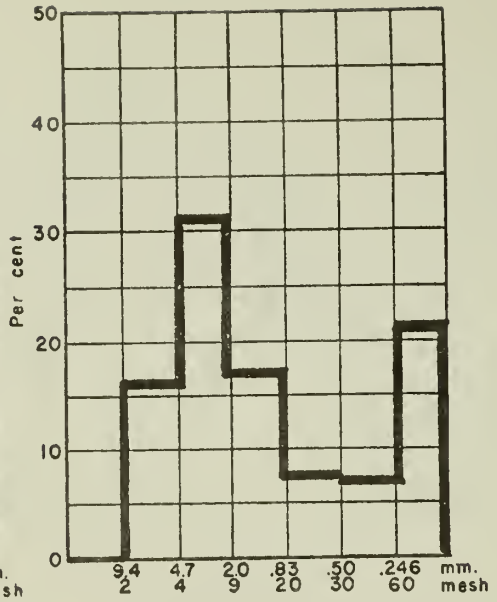

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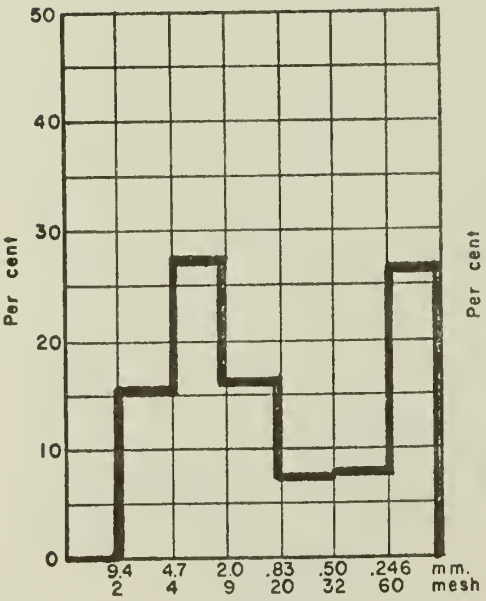

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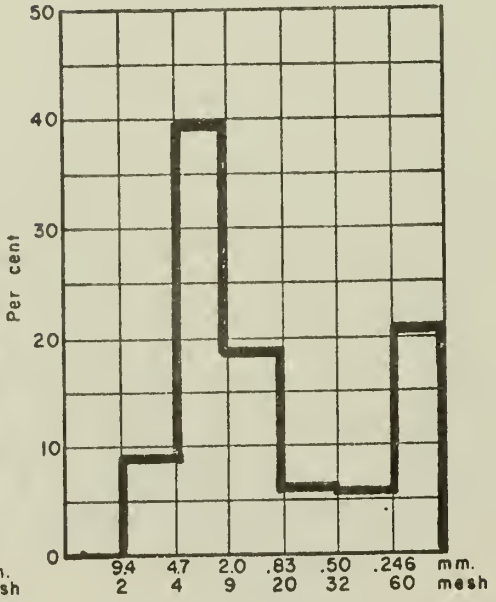

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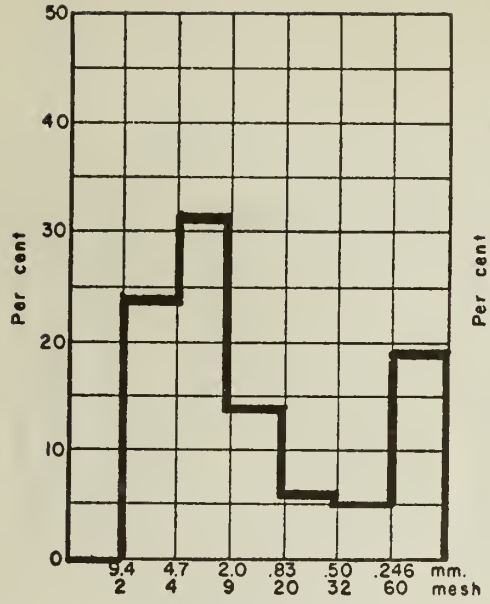

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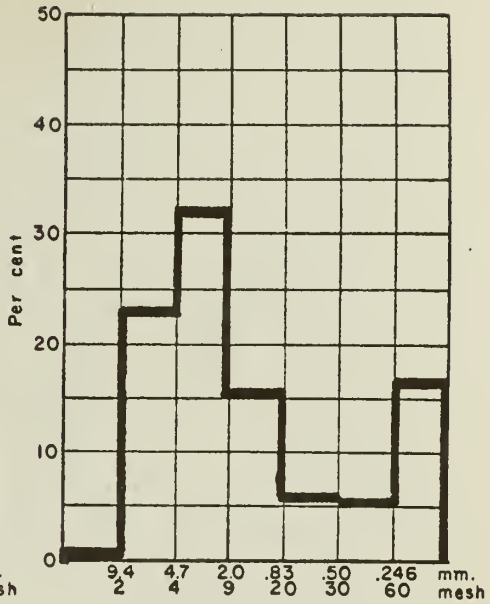

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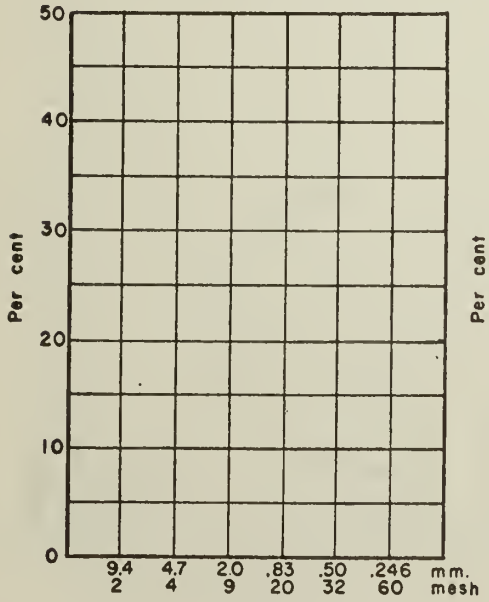

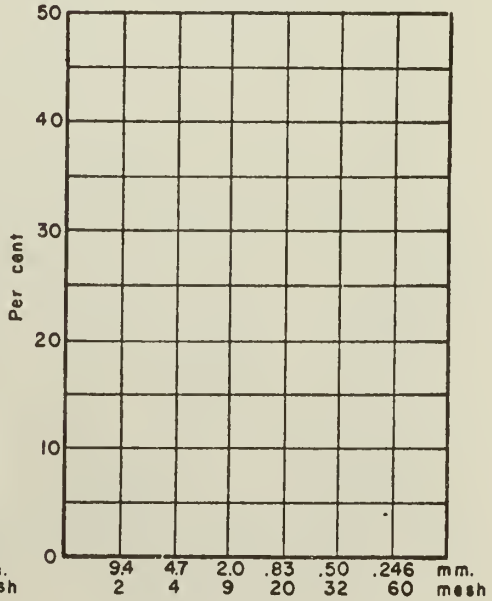

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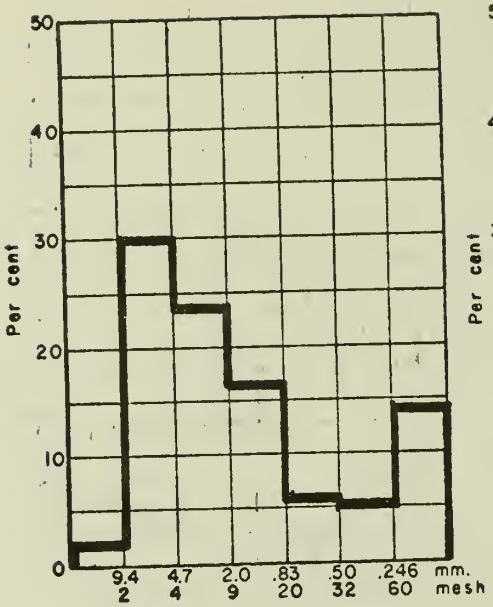

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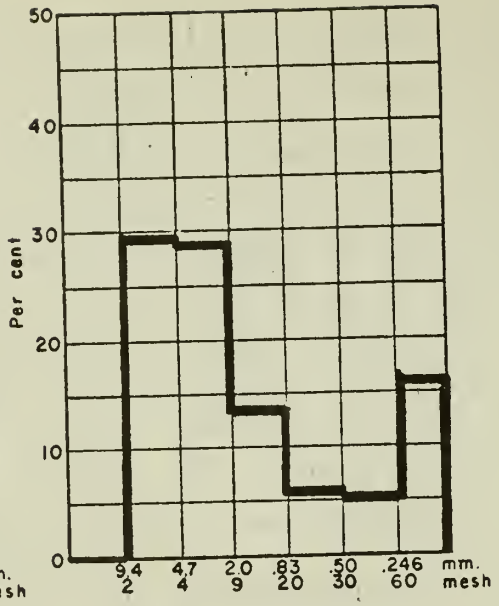

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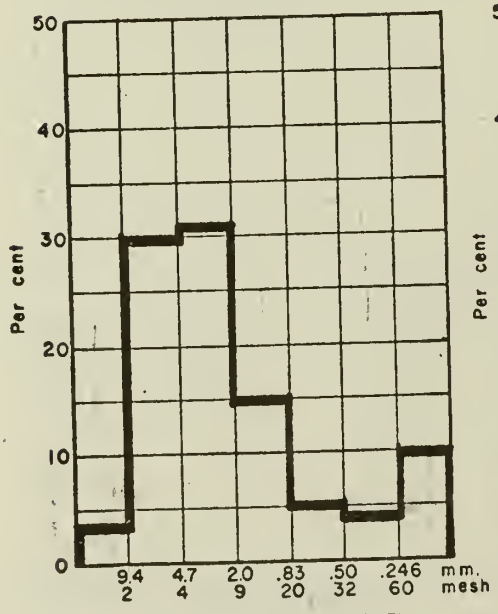
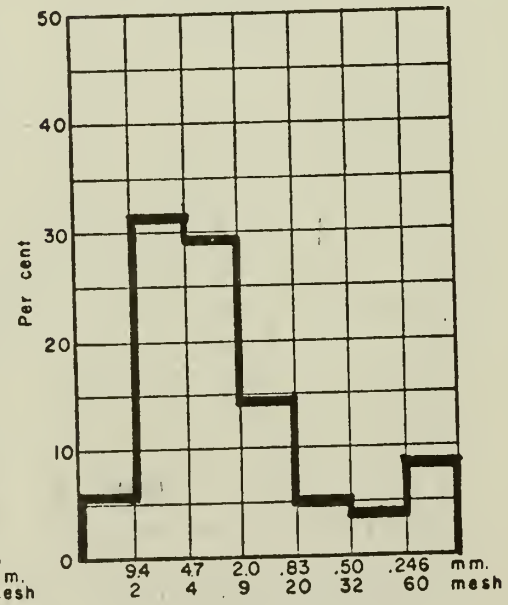
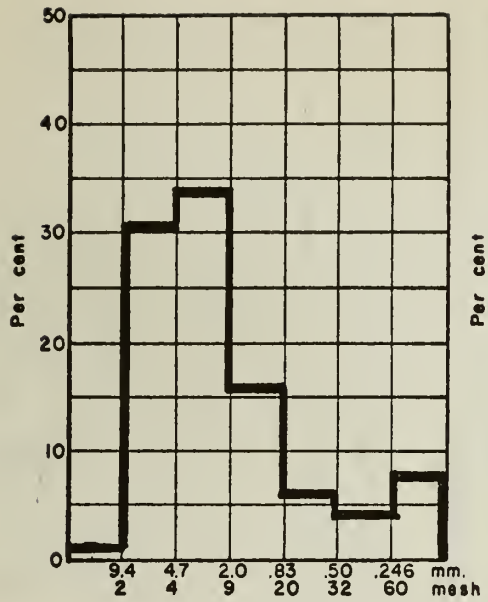


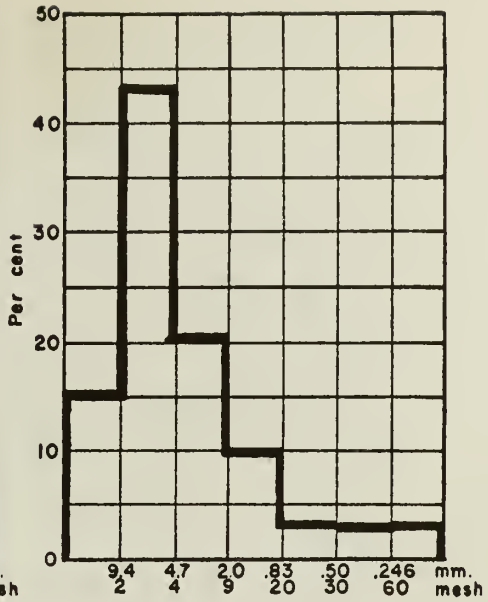
BC Mmc 10-13 (395-415)



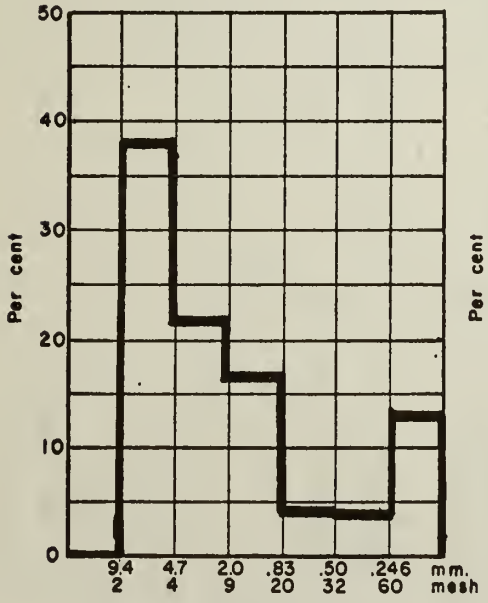
BC Mmc 14-18 (370-395)



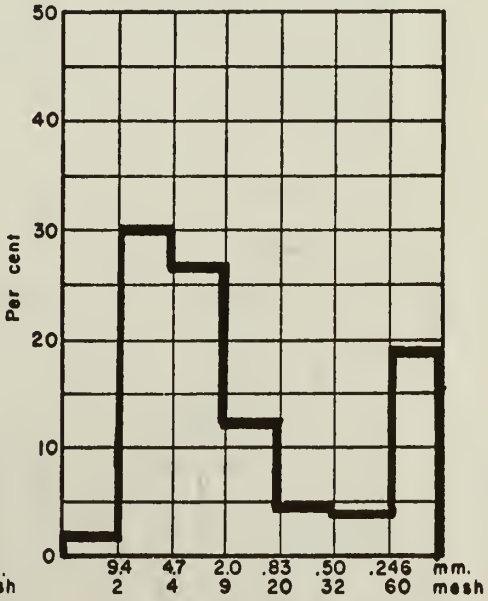
BC Mmc 19-24 (340-370)



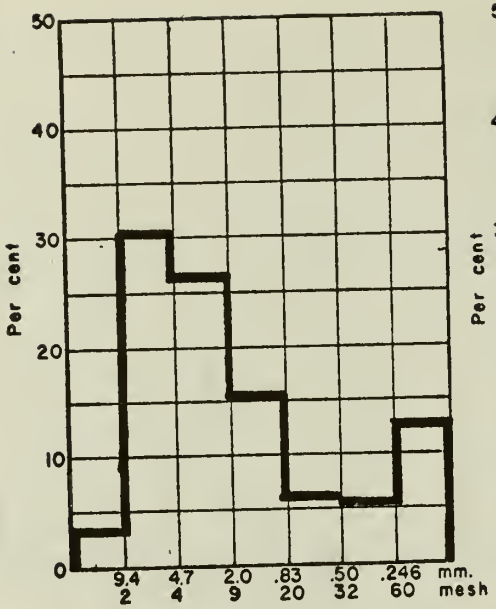
BC Mmc 29-32 (300-320)



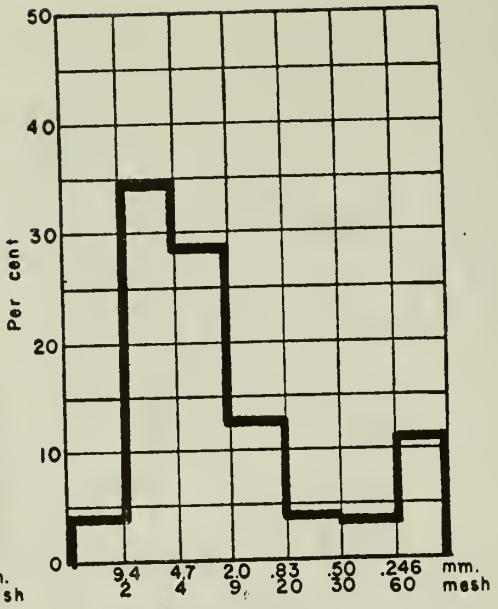
BC Mmc 33 (295-300)



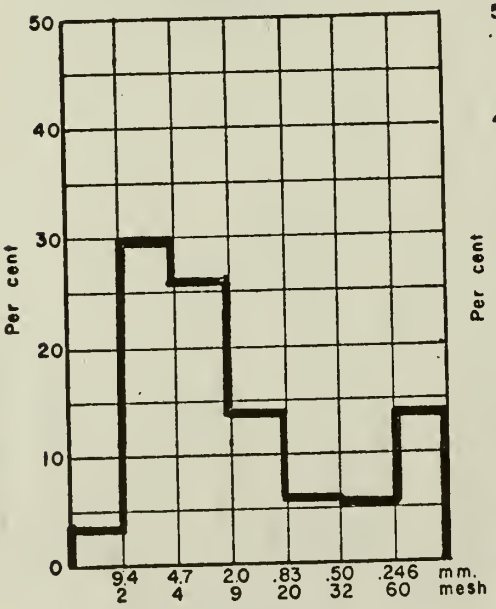
BC Mmc 47-52 (200-230)



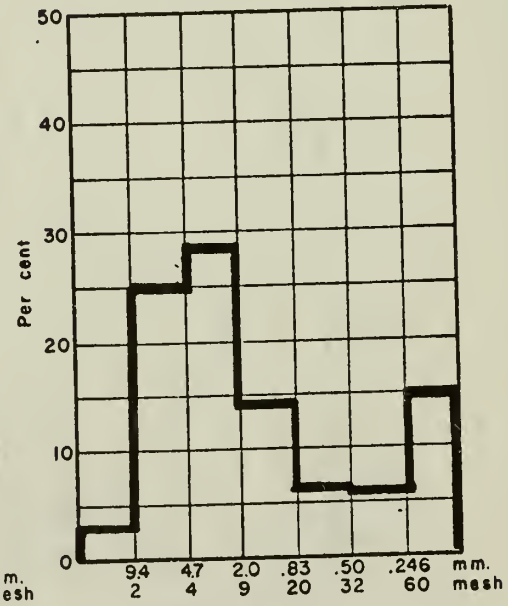
BC Mmc 53-55 (185-200)



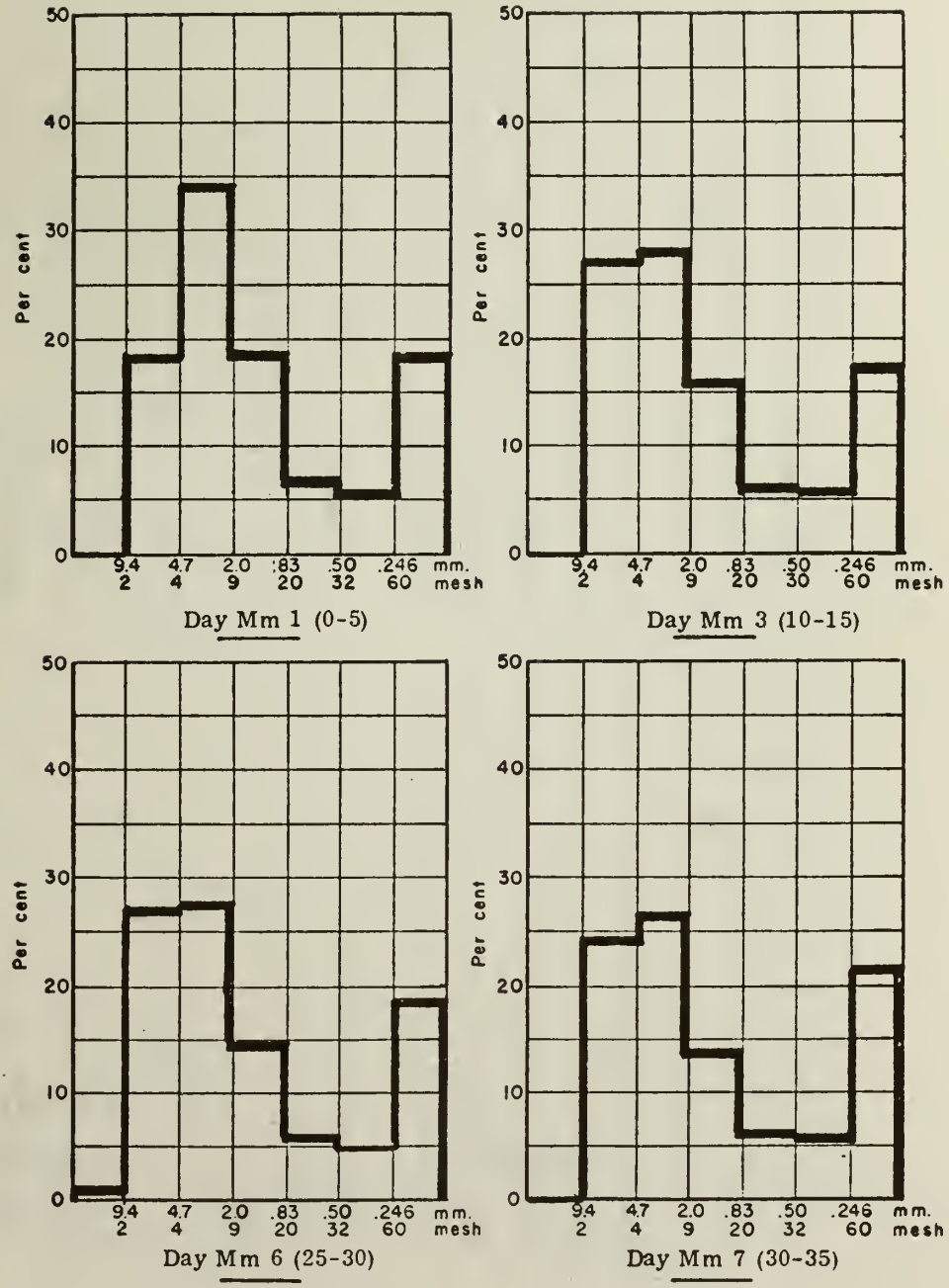
BC Mmc 56-60 (160-185)

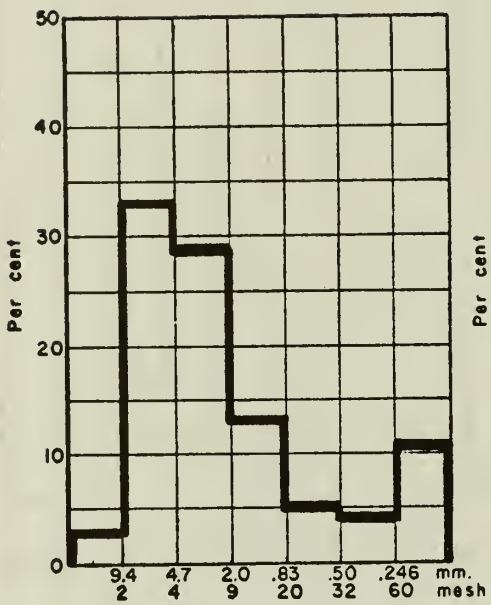


BC Mmc-lp 61-68 (120-160)

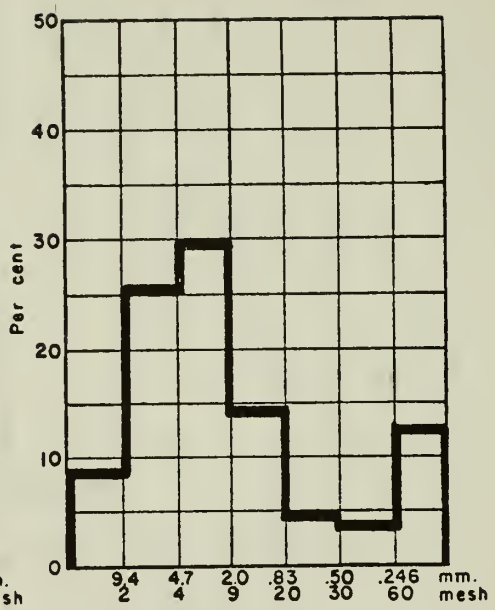


BC Mlp 81 (55-60)

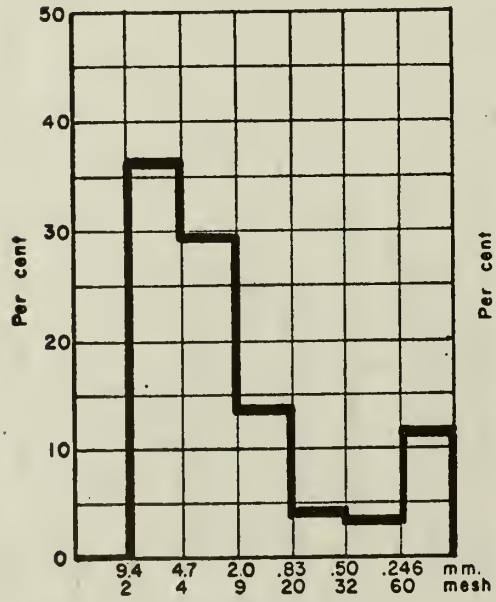

Per cent
0
10
20
30
40
50
9.4 4.7 2.0 .83 .50 .246 mm.
2 4 9 20 32 60 mesh
Day Mm 1 (0-5)
Day Mm 3 (10-15)
Day Mm 6 (25-30)
Day Mm 7 (30-35)



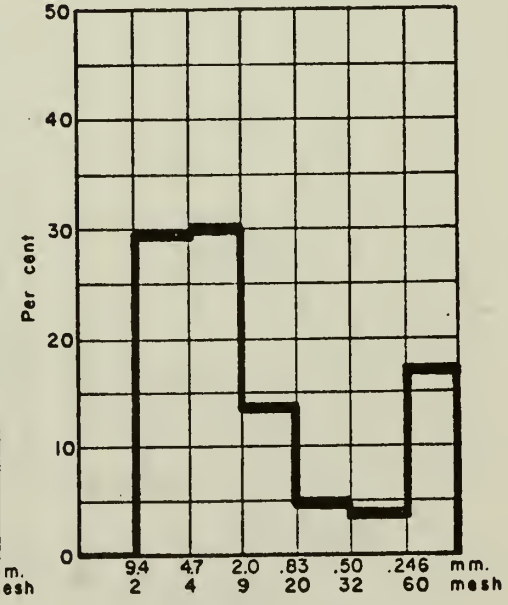
Day Mm 10 (45-50)



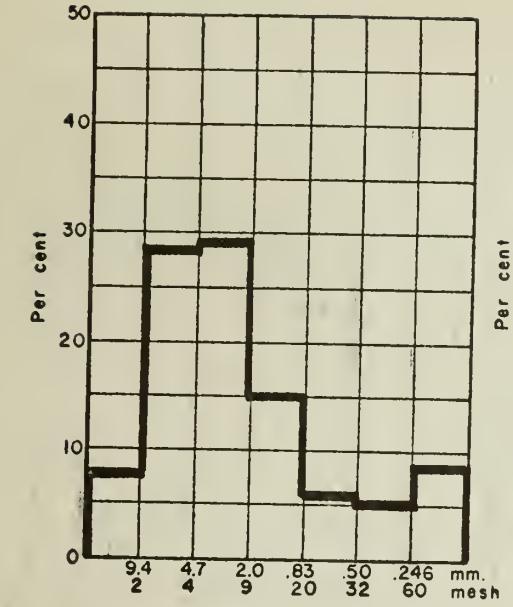
Day Mm 13 (60-65)



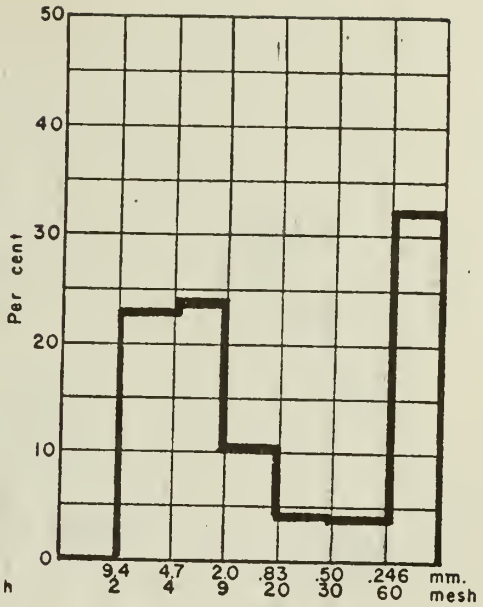
Day Mm 16 (75-80)



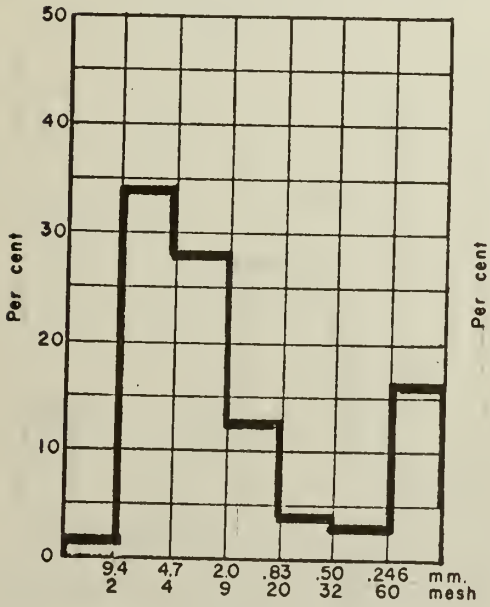
Day Mm 17 (80-85)



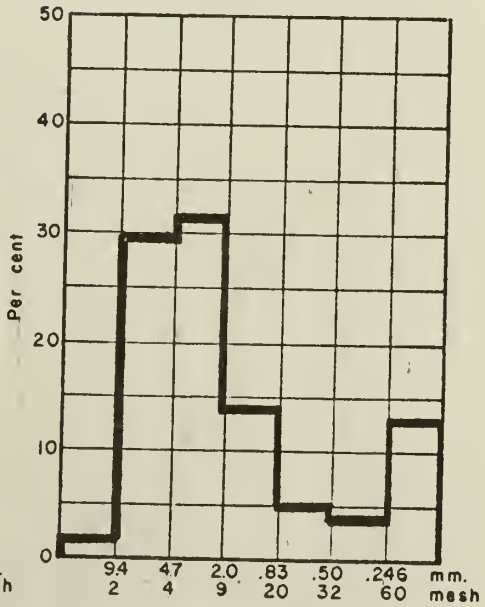
Day Mm 20 (95-100)



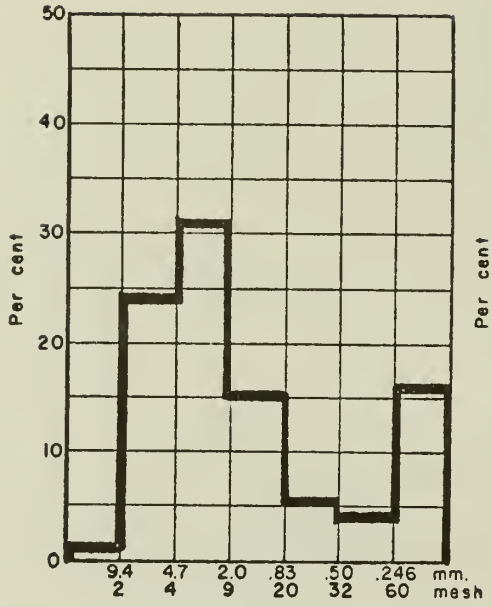
Day Mm 21 (100-105)



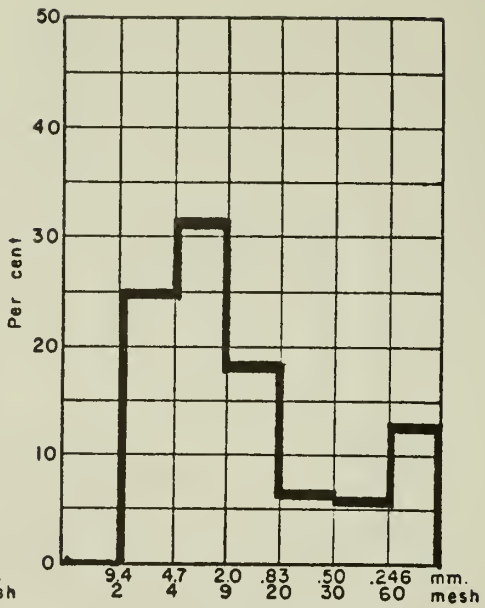
Day Mm 22 (105-110)



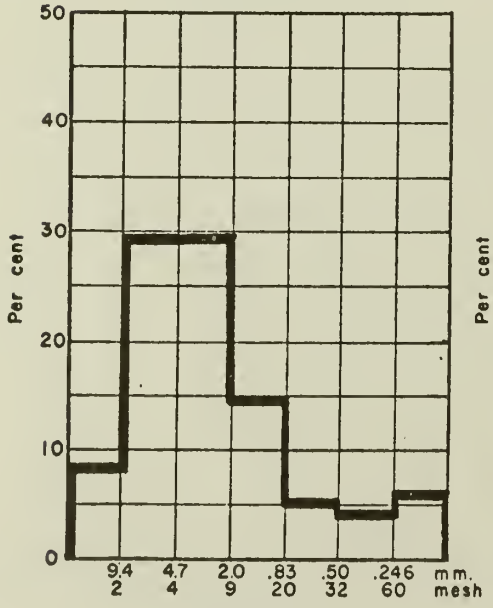
Day Mm 23 (110-115)



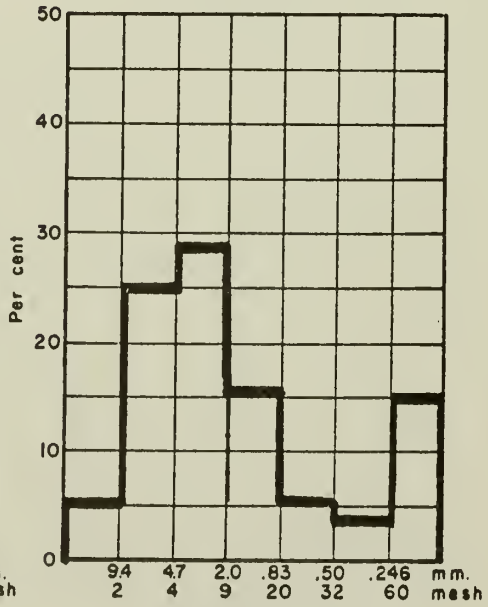
Day Mm 24 (115-120)



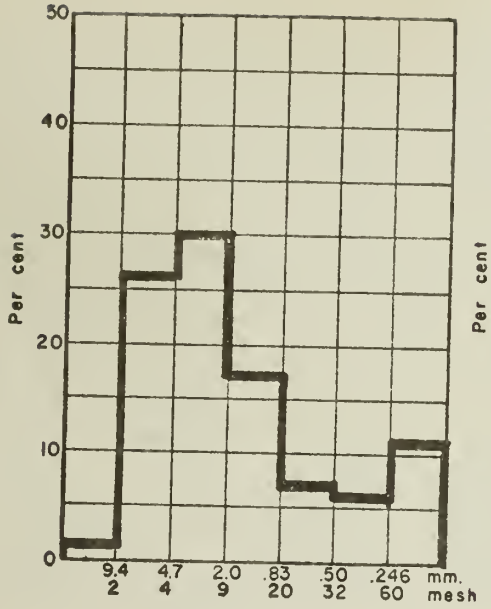
Day Mm 38 (185-190)



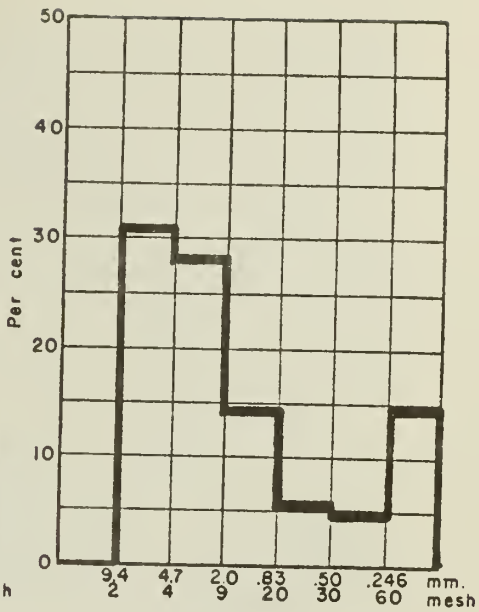
Day Mm 39 (190-195)



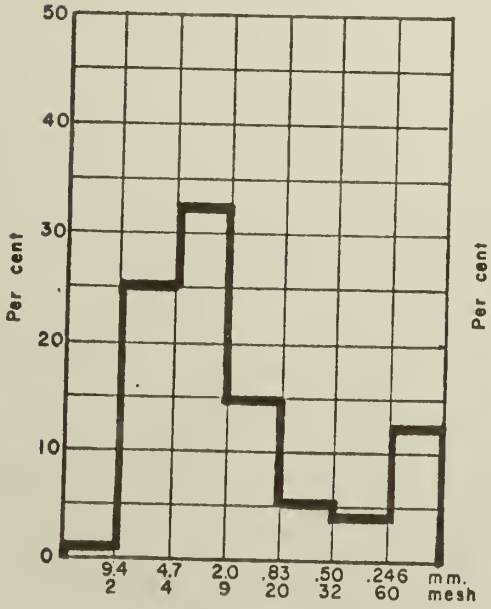
Day Mm 40 (195-200)



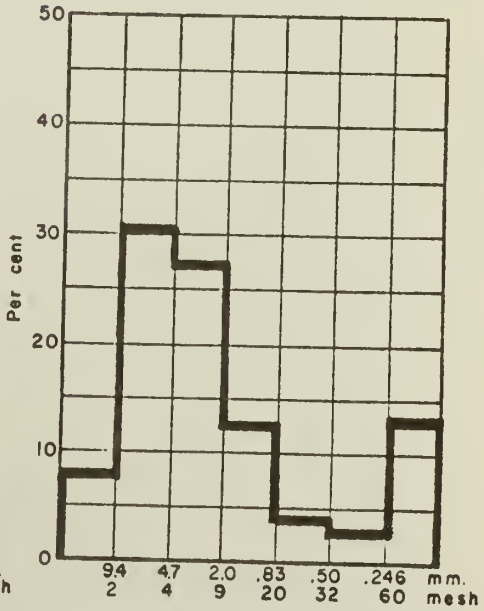
Day Mm 41 (200-205)



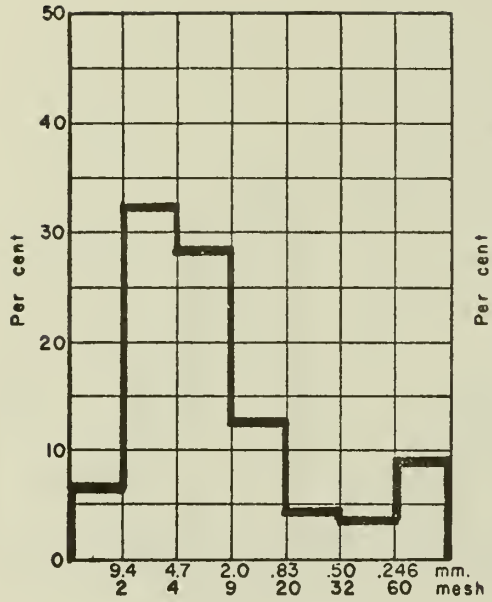
Day Mm 43 (210-215)



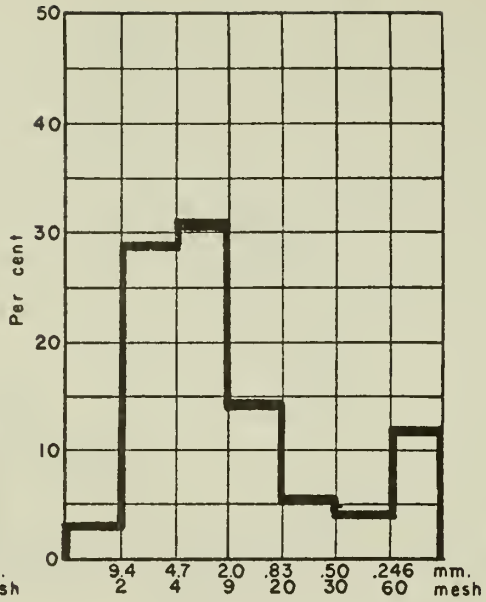
Day Mm 44 (215-220)



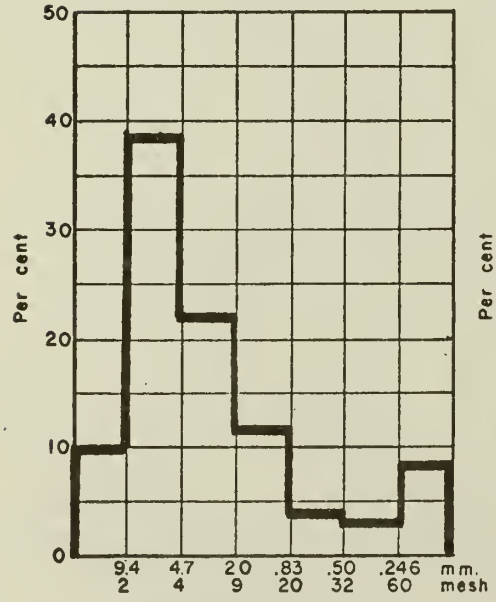
Day Mm 45 (220-225)



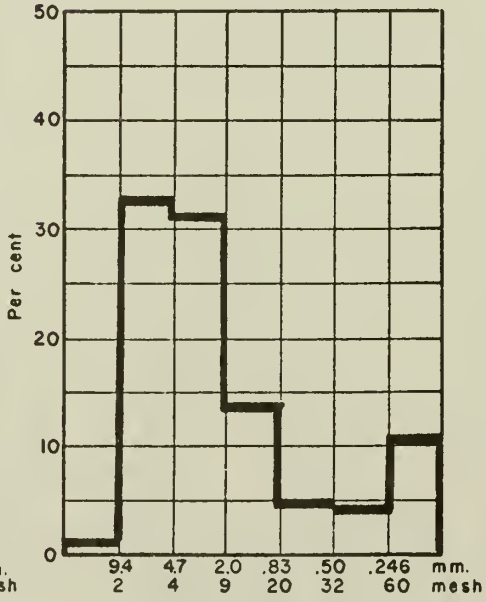
Day Mm 46 (225-230)



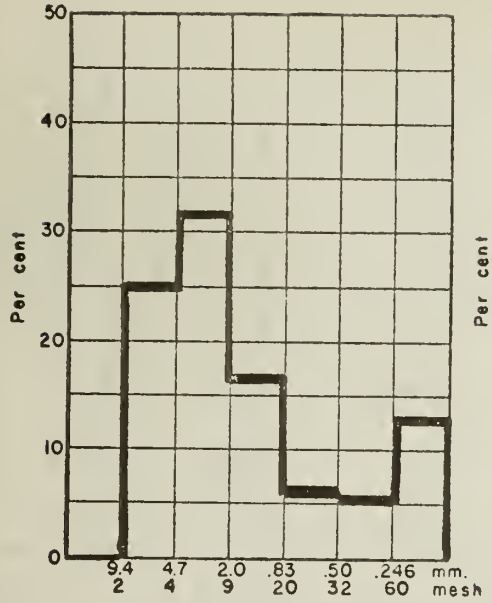
Day Mm 48 (235-240)



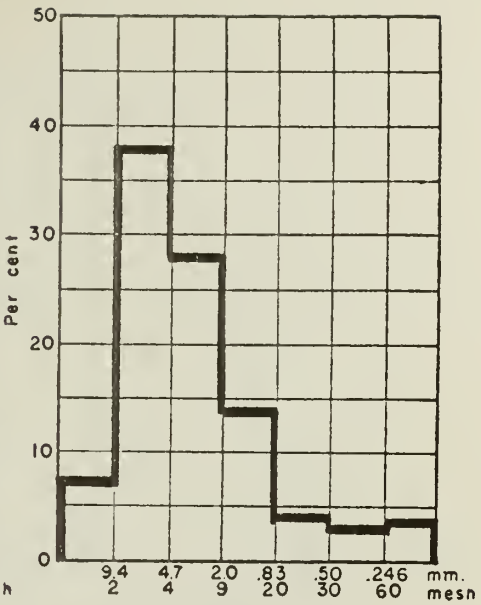
Day Mm 49 (240-245)



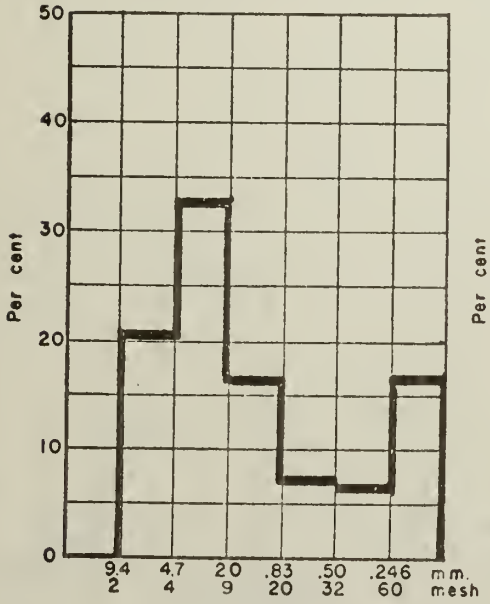
Day Mm 50 (245-250)



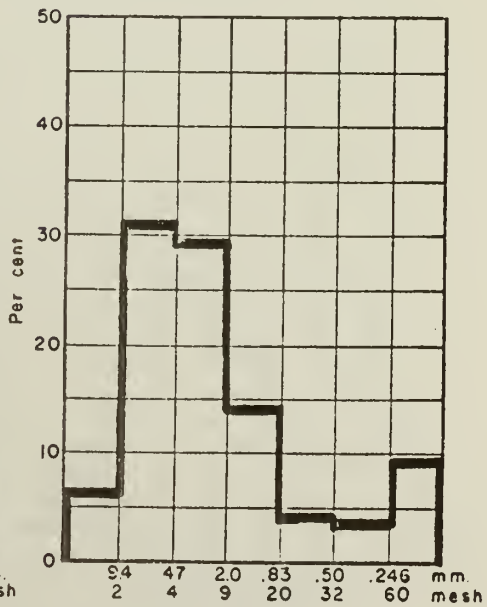
Day Mm 51 (250-255)



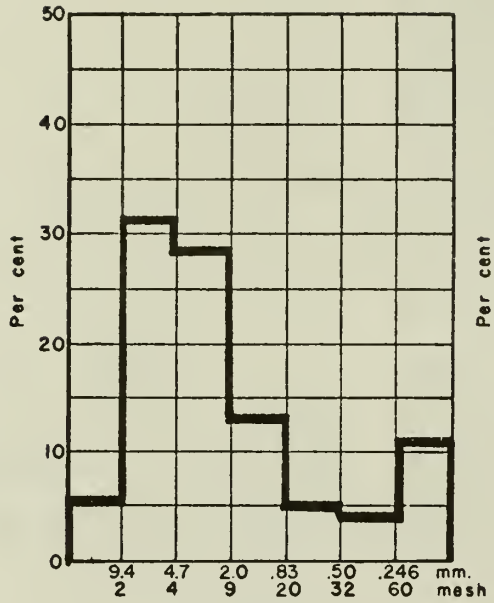
Day Mm 52 (255-260)



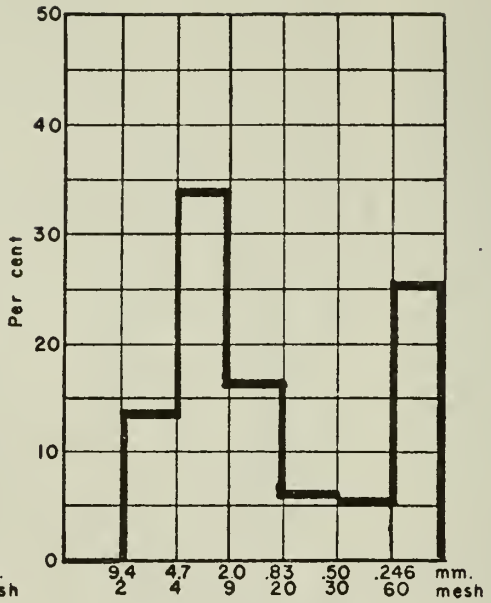
Day Mm 53 (260-265)



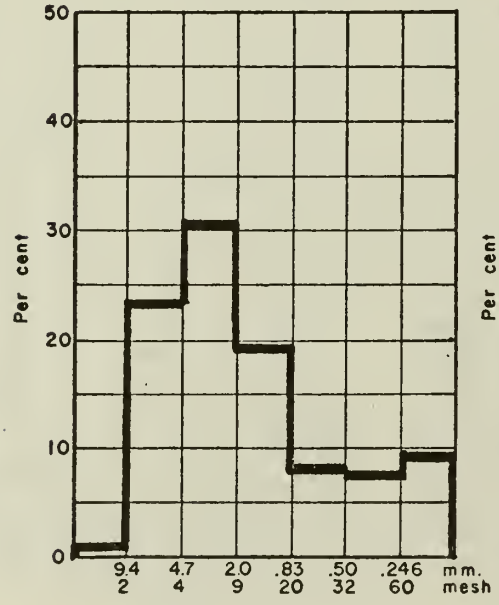
Day Mm 54 (265-270)



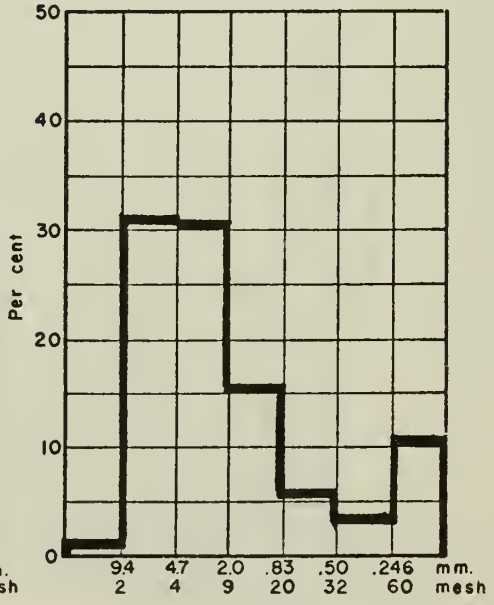
Day Mm 56 (275-280)



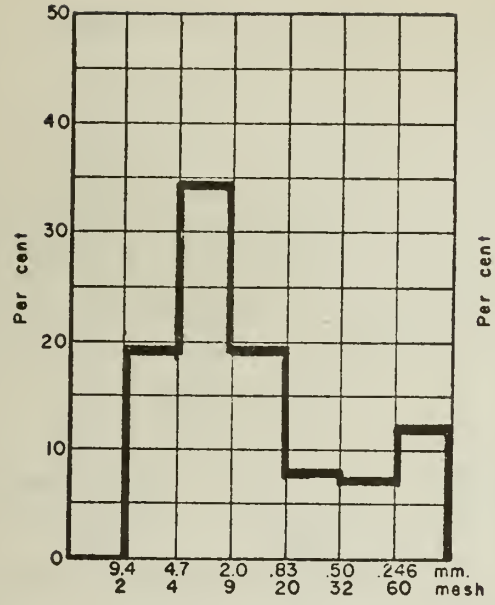
Day Mm 57 (280-285)



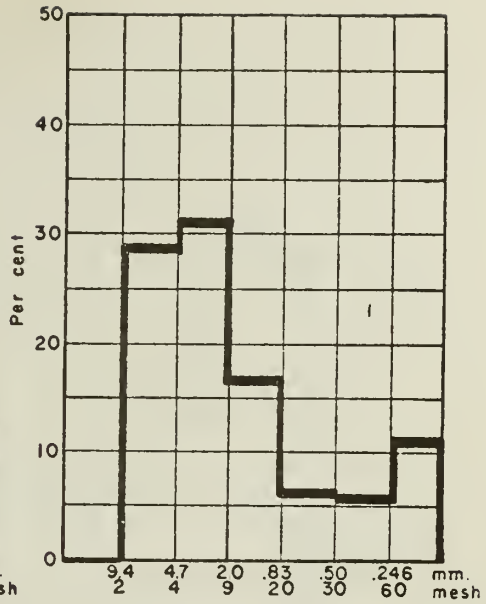
Day Mm 58 (285-290)



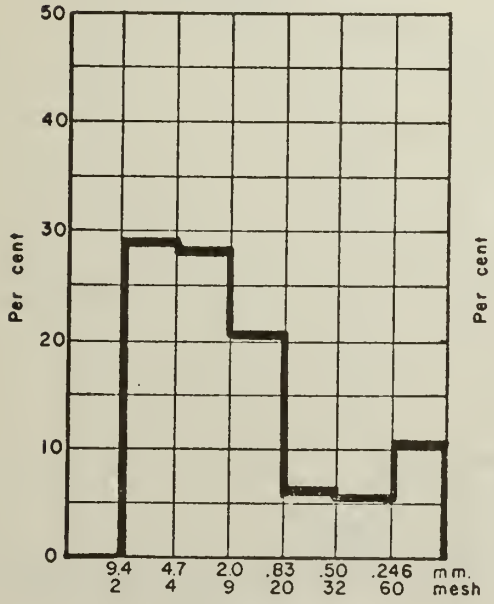
Day Mm 59 (290-295)



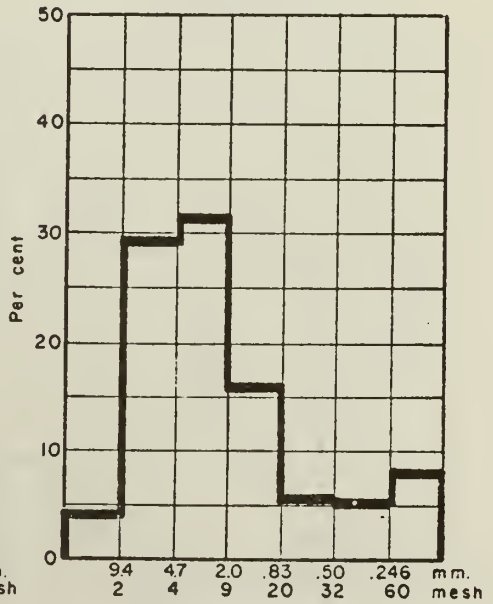
Day Mm 60 (295-300)



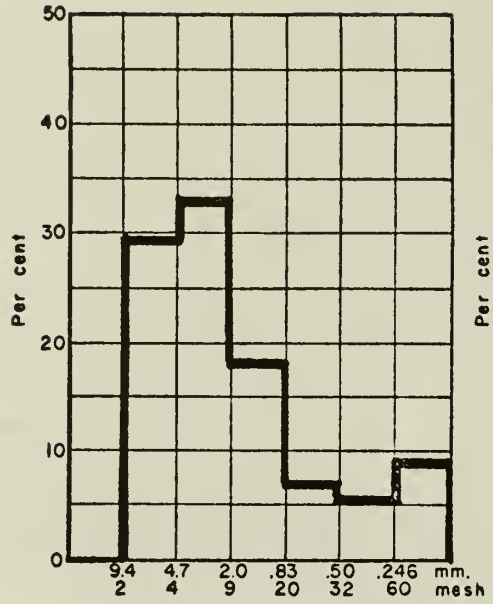
Day Mm 61 (300-305)



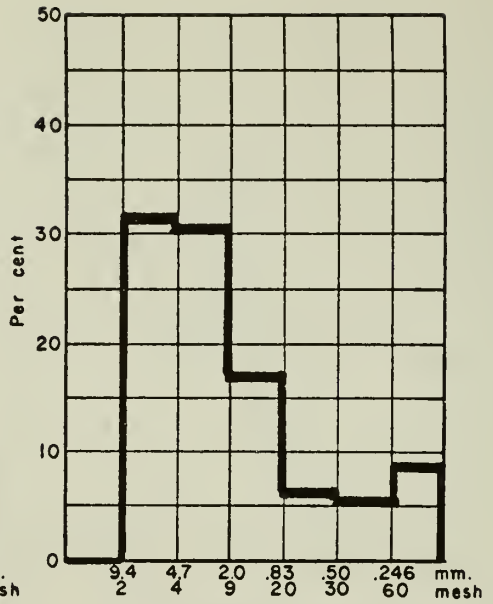
Repeat Day Mm 61 (300-305)



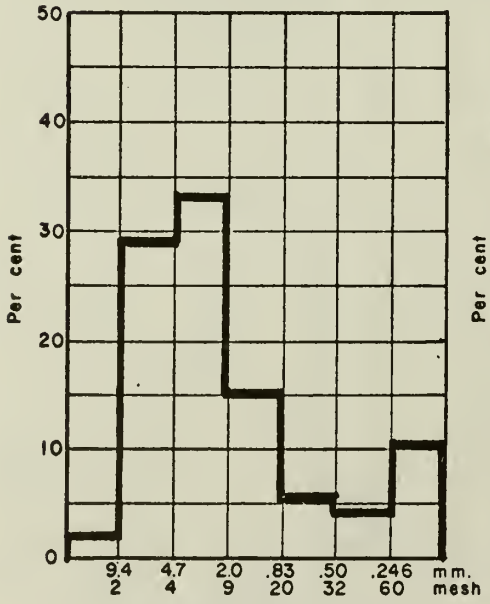
Day Mm 63 (310-315)



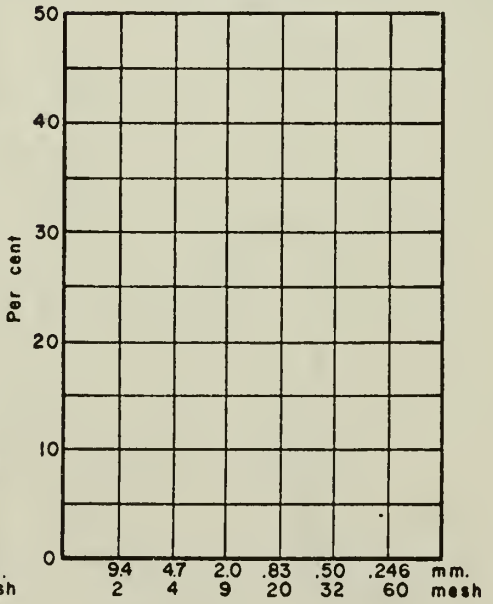
Day Mm 65 (320-325)

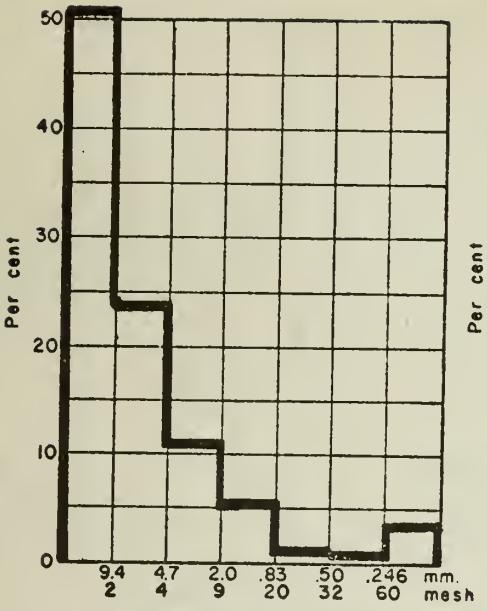


Day Mm 66 (325-330)

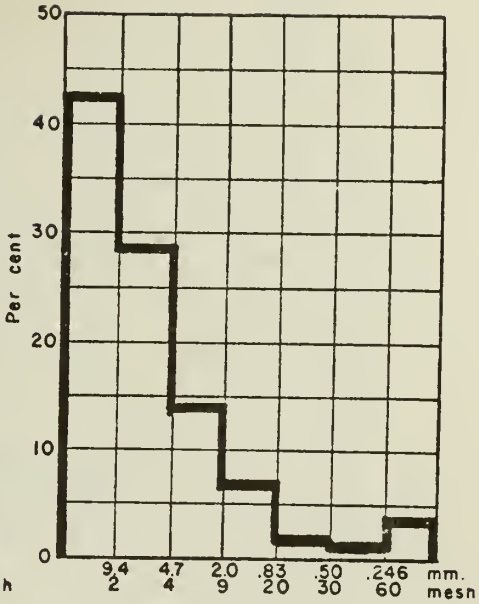


Day Mm 67 (330-335)

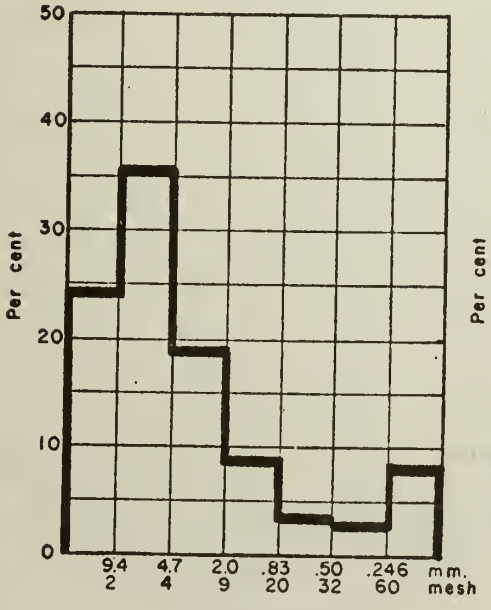




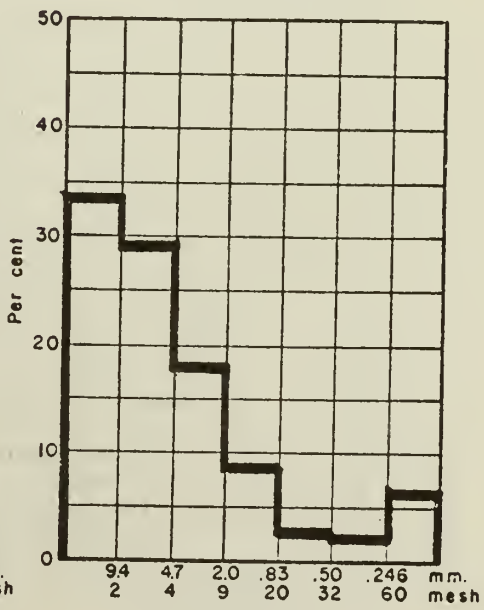
Day Ob 3 (10-15)



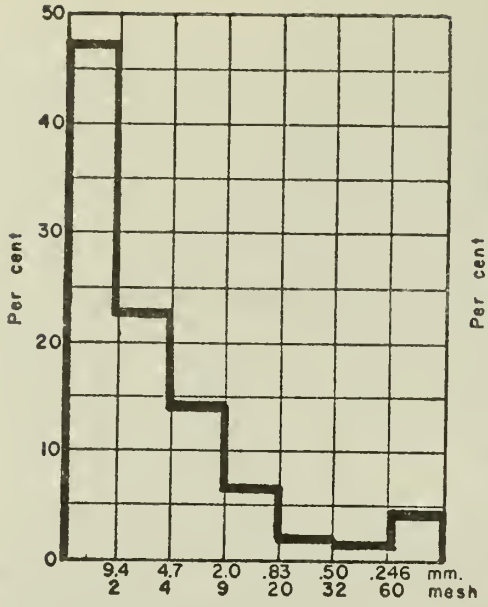
Day Ob 8 (35-40)



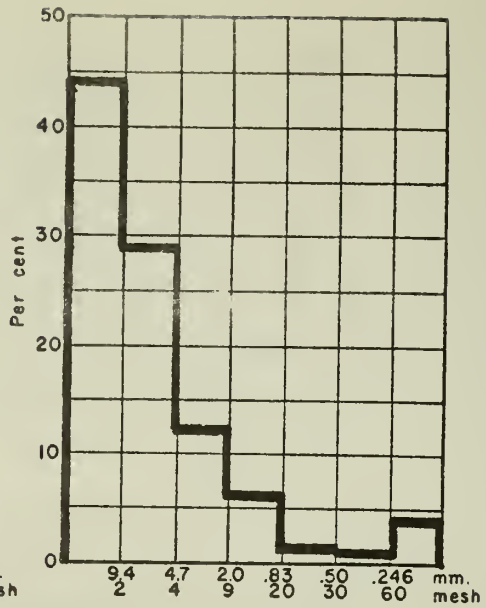
Day Ob 14 (65-70)



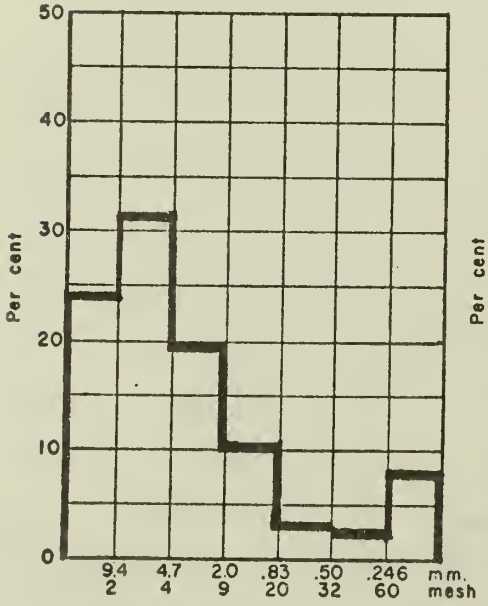
Day Ob 15 (70-75)



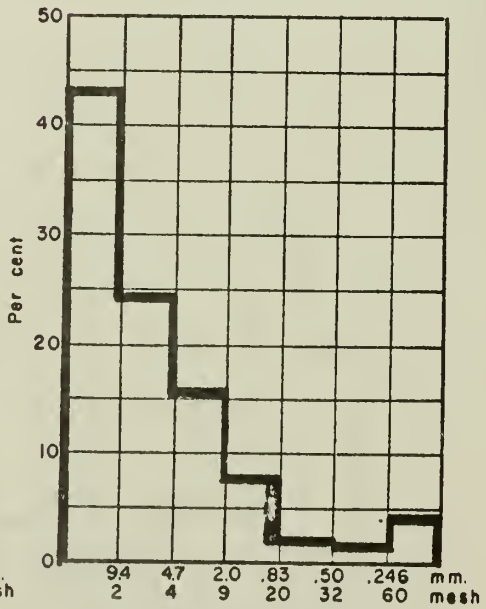
Day Ob 18 (85-90)



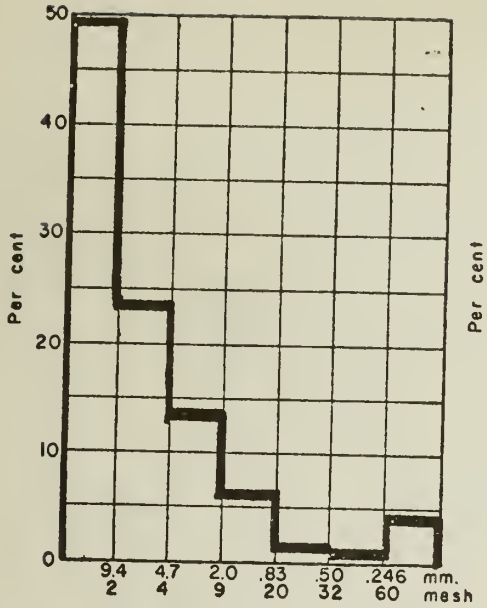
Day Ob 22 (105-110)



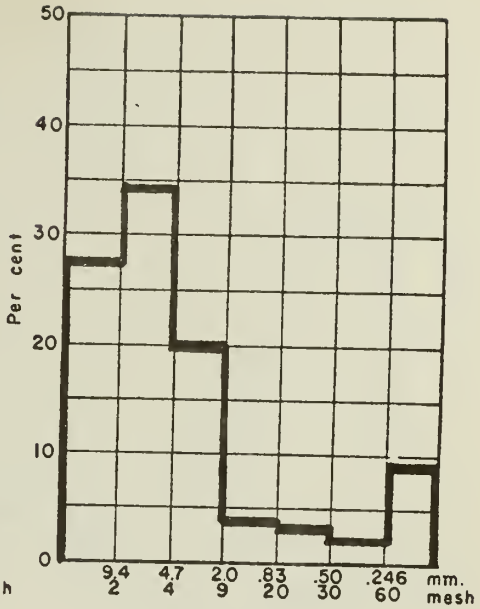
Day Ob 24 (115-120)



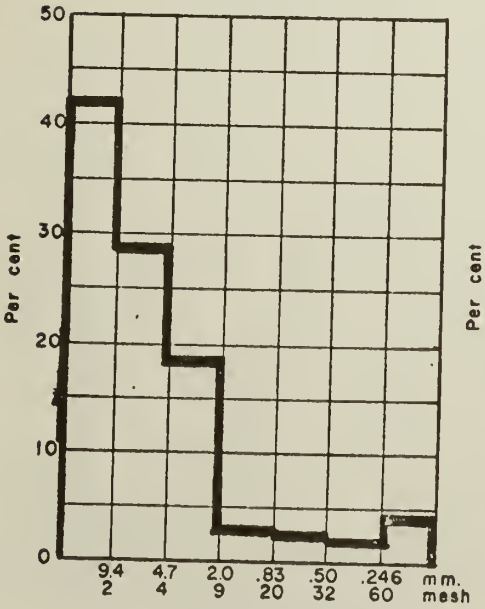
Day Ob 29 (140-145)



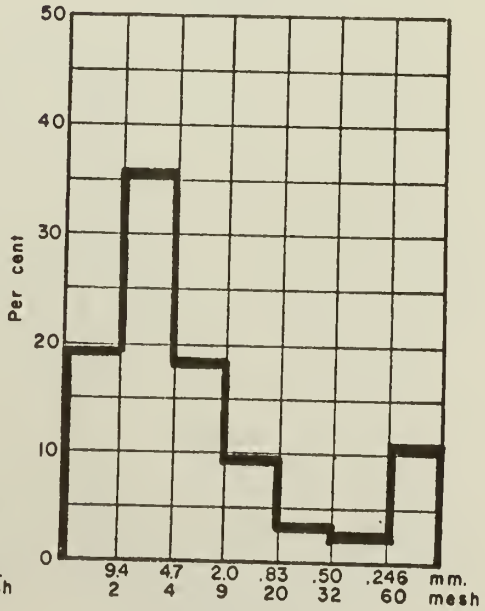
Day Ob 35 (170-175)



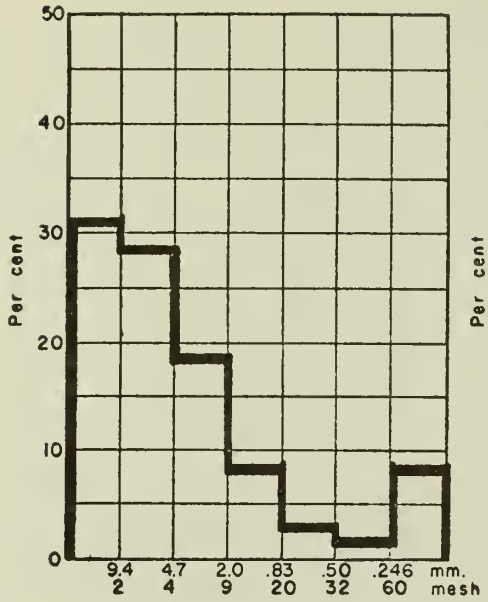
Day Ob 37 (180-185)



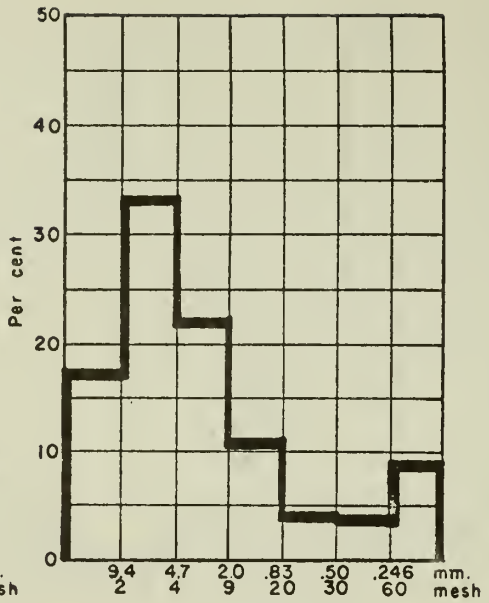
Day Ob 38 (185-190)



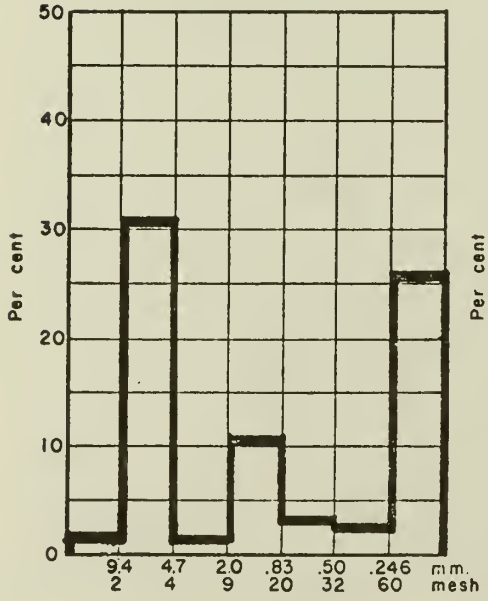
Day Ob 43 (210-215)



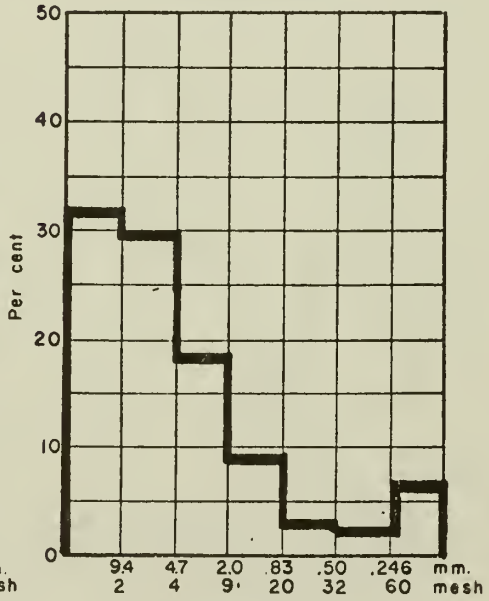
Day Ob 44 (215-220)



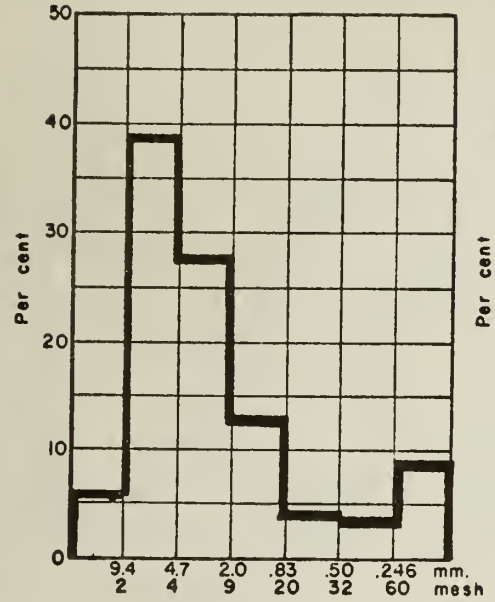
Day Ob 46 (225-230)



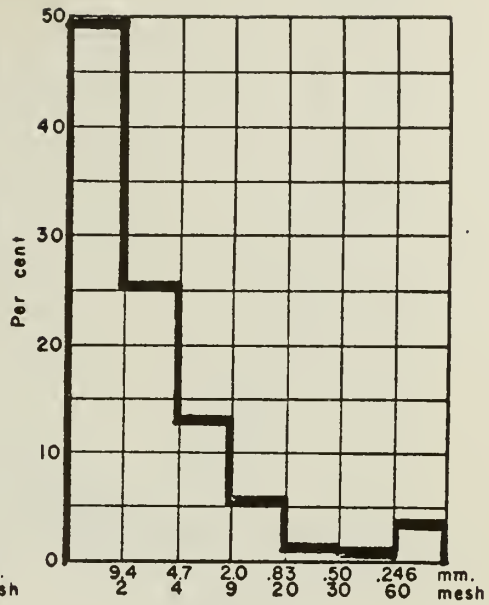
Day Ob 48 (235-240)



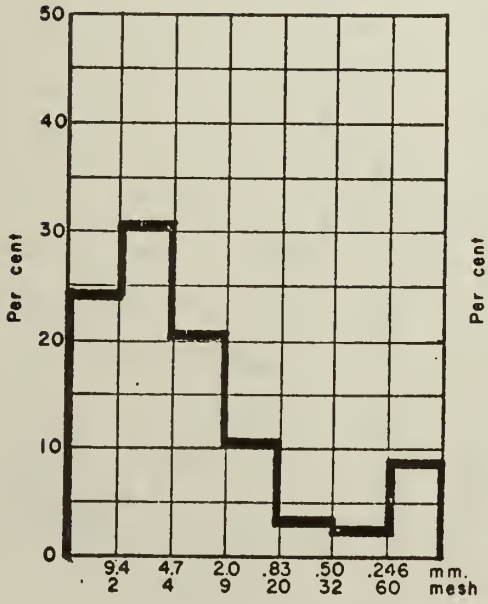
Day Ob 53 (260-265)



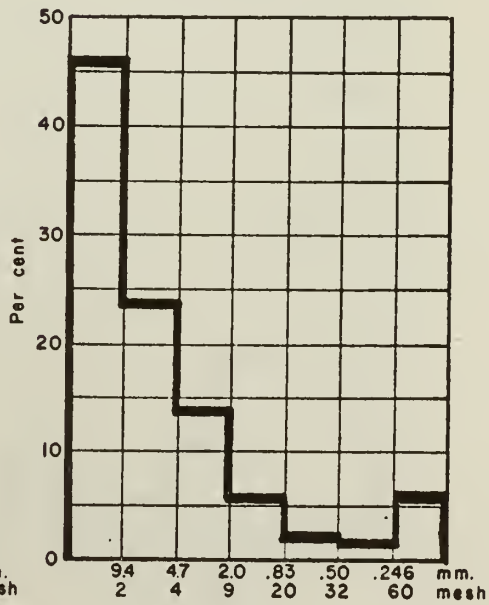
Day Ob 55 (270-275)



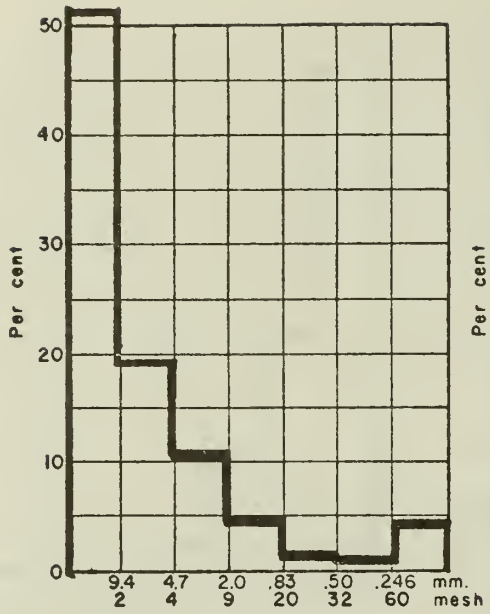
Day Ob 60 (295-300)



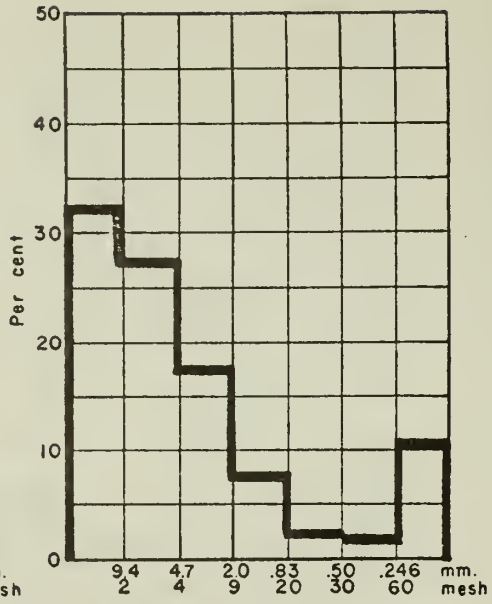
Day Ob 63 (310-315)



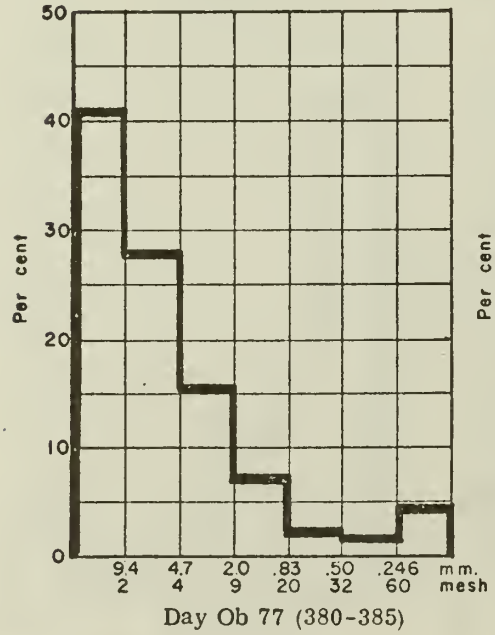
Day Ob 66 (325-330)



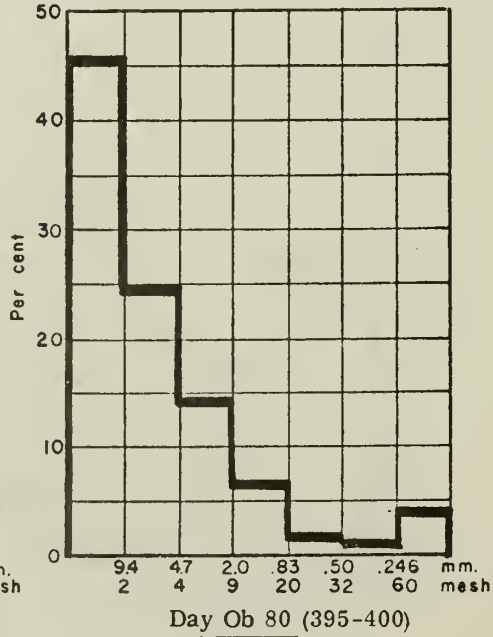
Day Ob 69 (340-345)



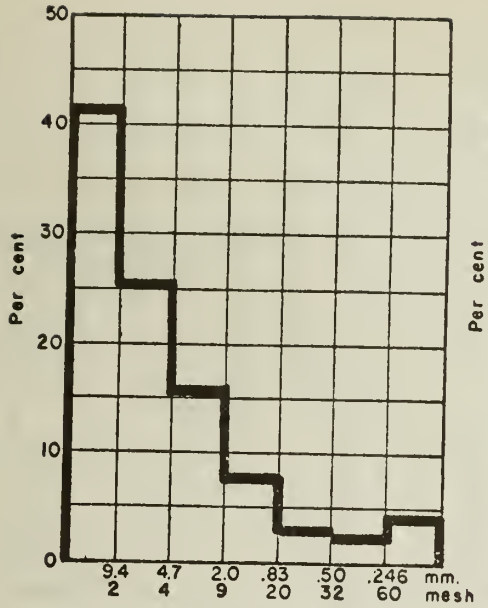
Day Ob 74 (365-370)

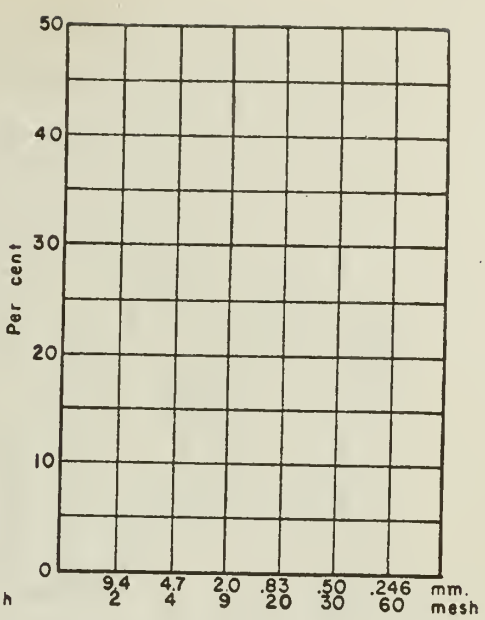


Day Ob 77 (380-385)

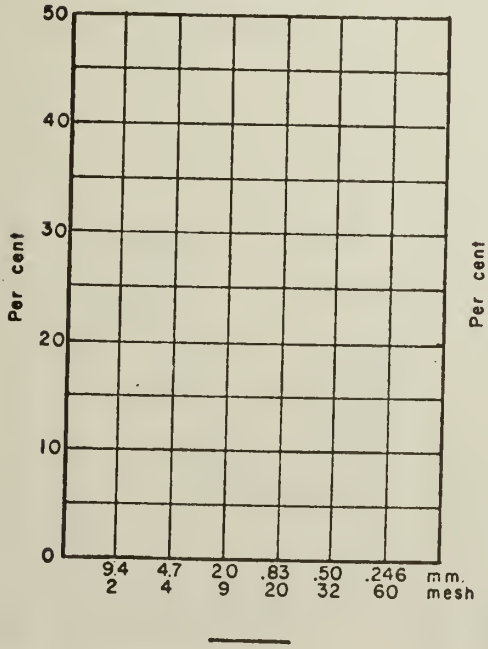


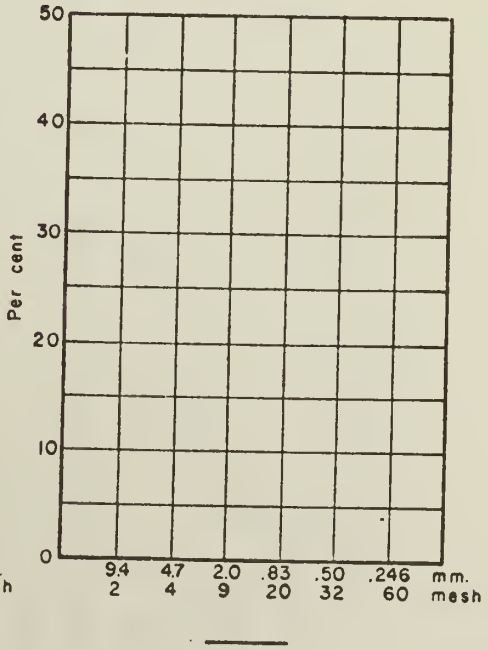
Day Ob 80 (395-400)

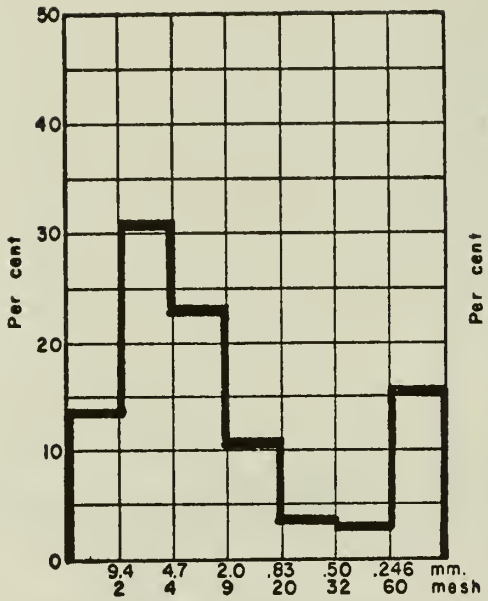




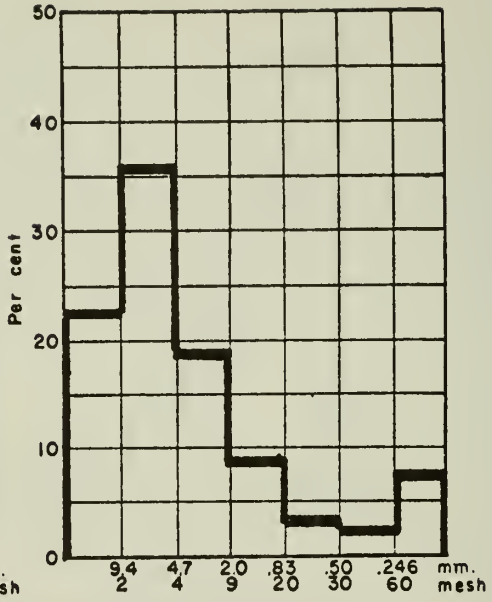
Day Ob 82 (405-410)



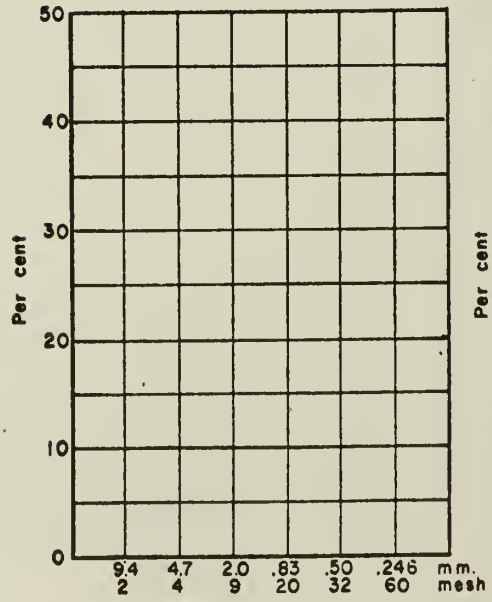


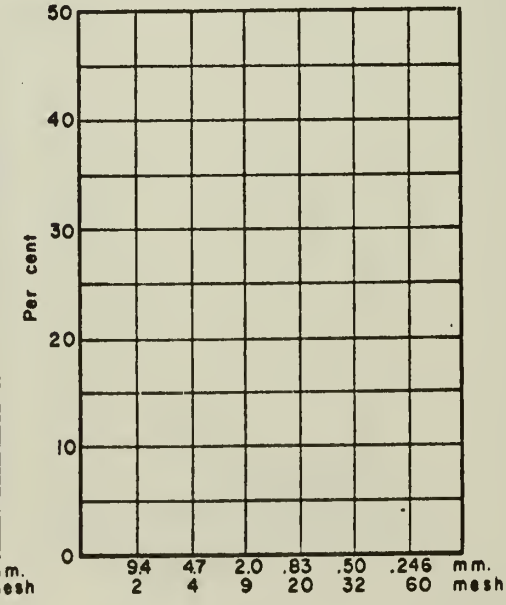


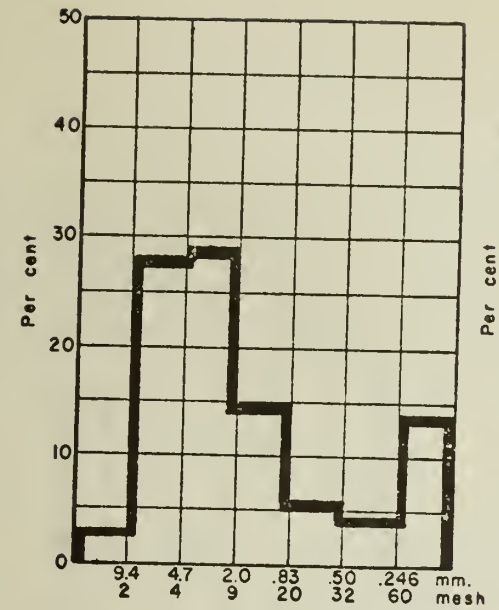
Whitewood Ow 16 (5-10)



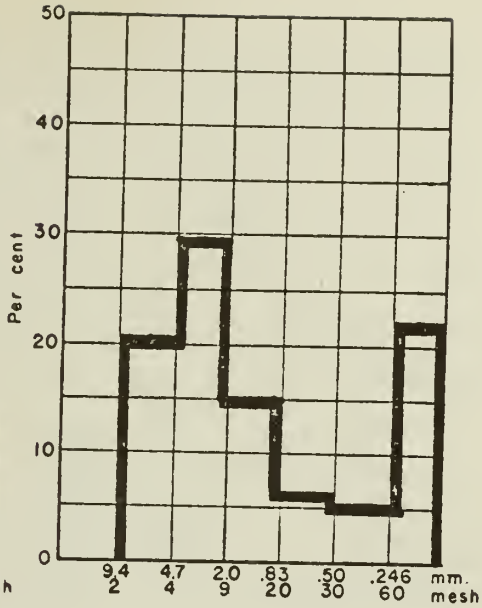
Whitewood Ow 17 (10-15)



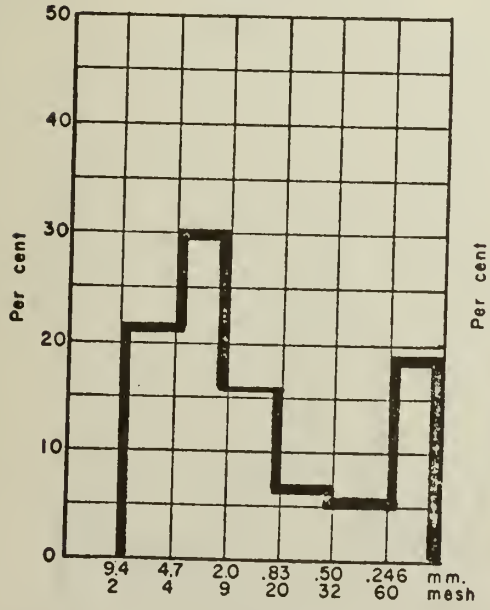




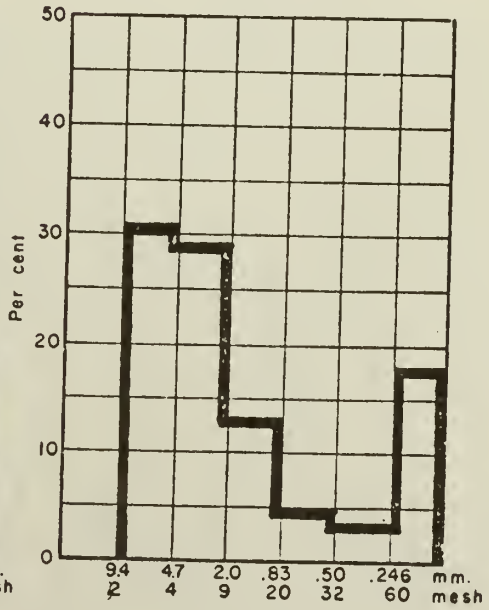
WhCCp3



WhCCp7



WhCCp9



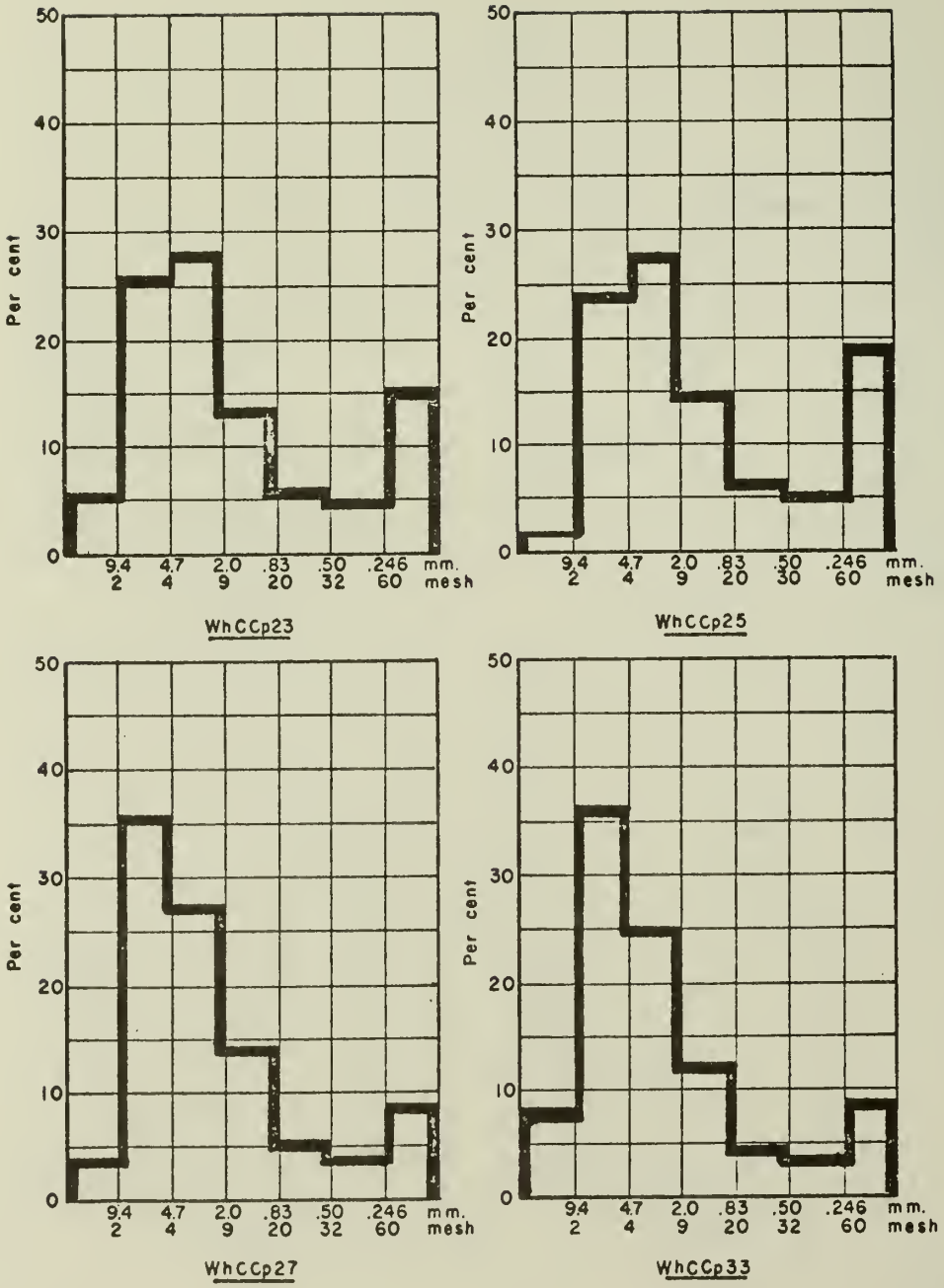
WhCCp16

WhCCp3- 5' to 10'

WhCCp7- 25' to 30'

WhCCp9- 35' to 40'

WhCCp16- 70' to 75'

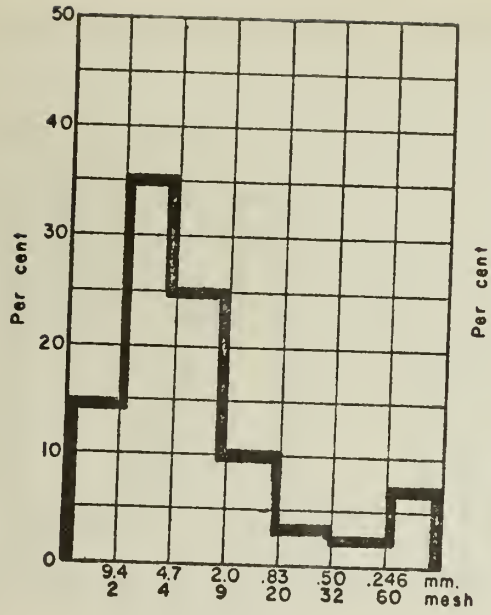


WhCCp23 – 105' to 110'

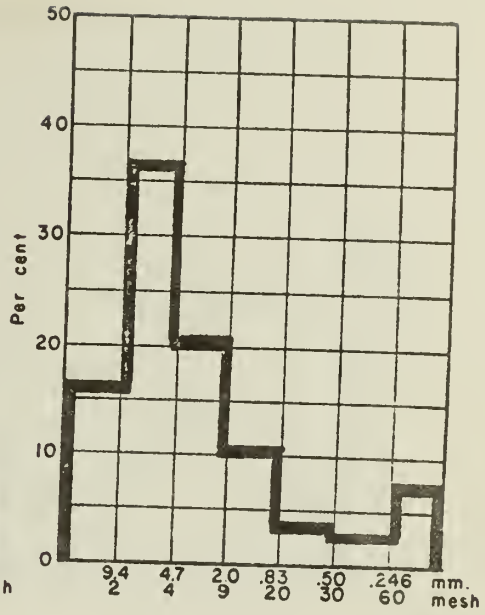
WhCCp25 – 125' to 130'

WhCCp27 – 135' to 140'

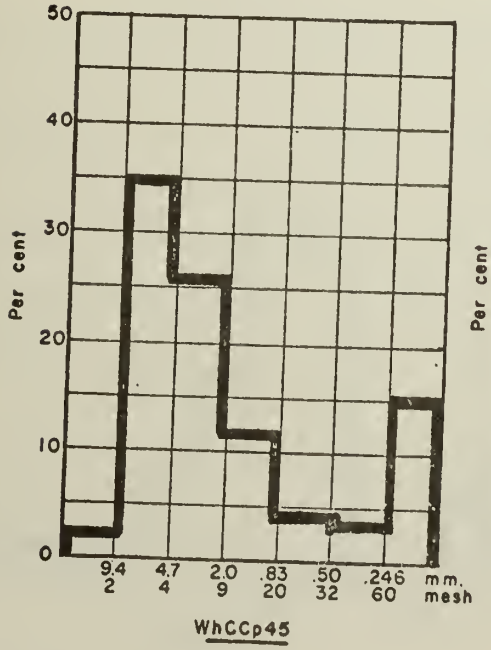
WhCCp33 – 165' to 170'



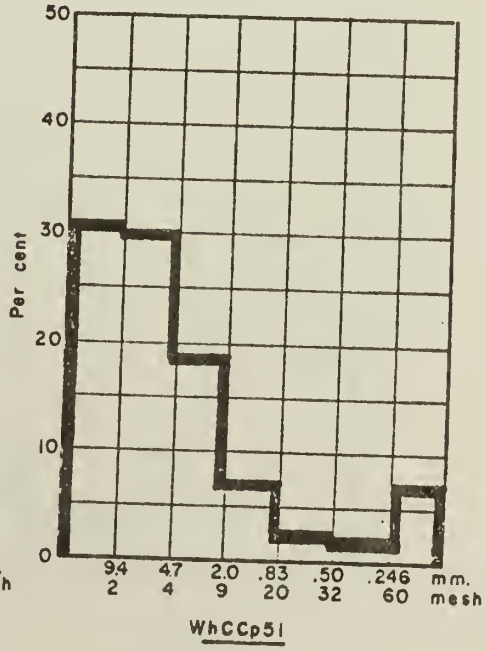
WhCCp37



WhCCp41



WhCCp45



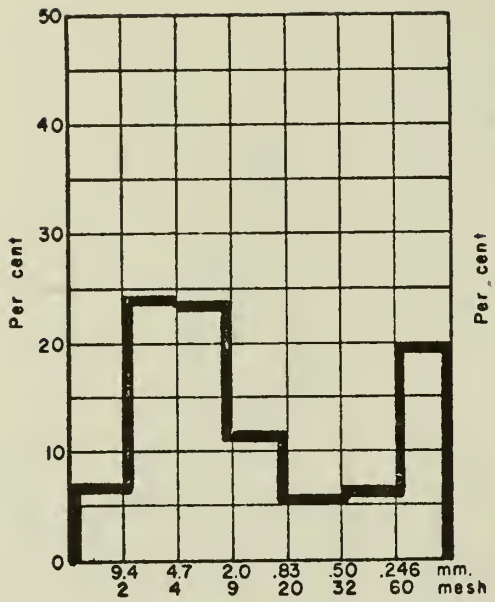
WhCCp51

WhCCp37 – 185' to 190'

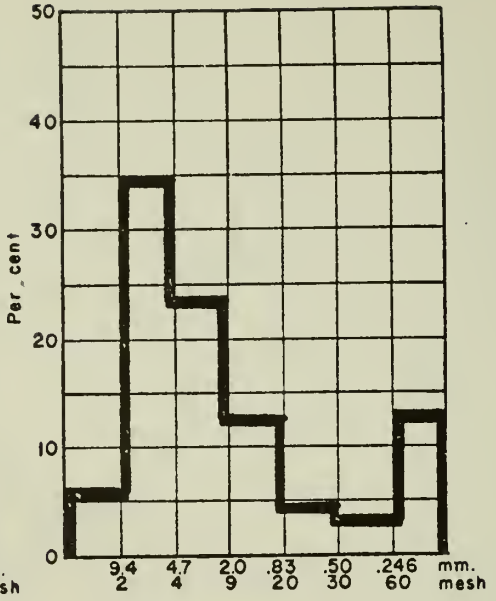
WhCCp41 – 205' to 210'

WhCCp45 – 225' to 230'

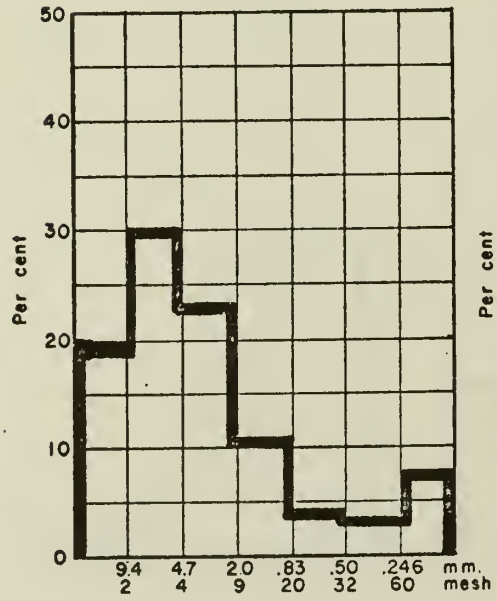
WhCCp51 – 255' to 260'



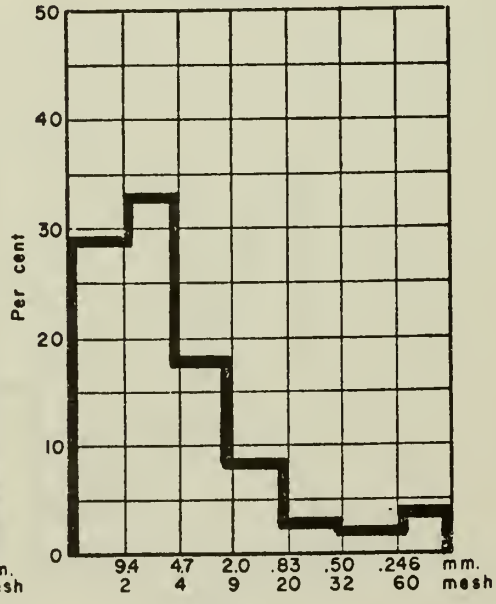
WhCCp56



WhCCp60



WhCCp67



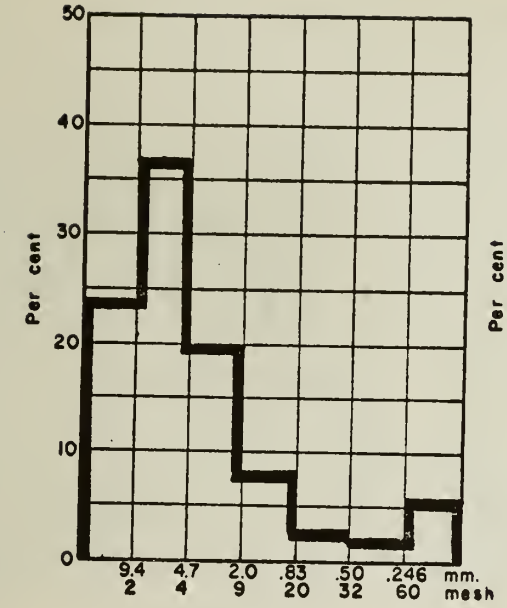
WhCCp73

WhCCp56 – 280' to 285'

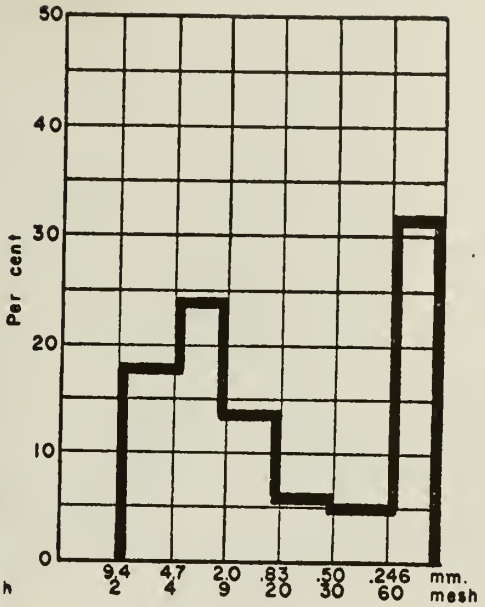
WhCCp60 – 300' to 305'

WhCCp67 – 335' to 340'

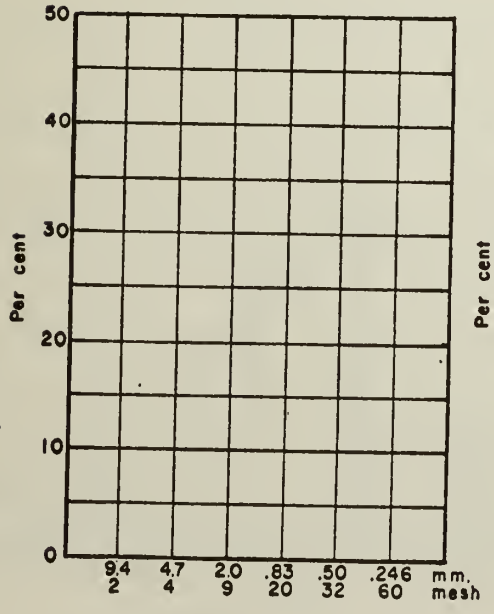
WhCCp73 – 365' to 370'

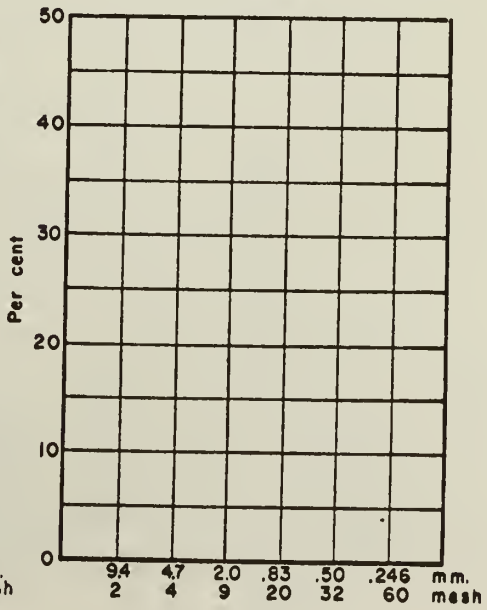


WhCCp77



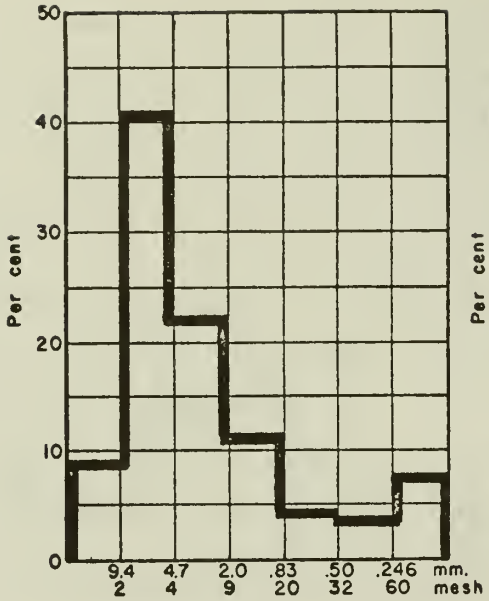
WhCCp85



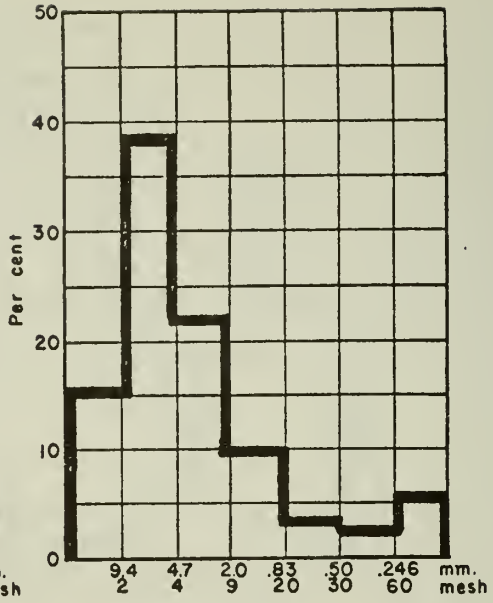


WhCCp77—390' to 395'

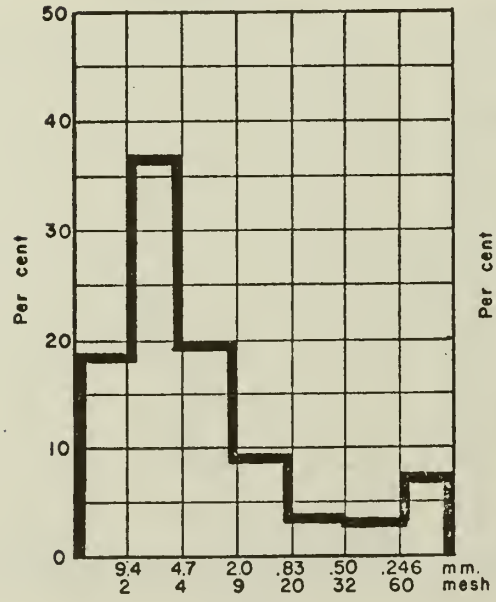
WhCCp85—440' to 445'



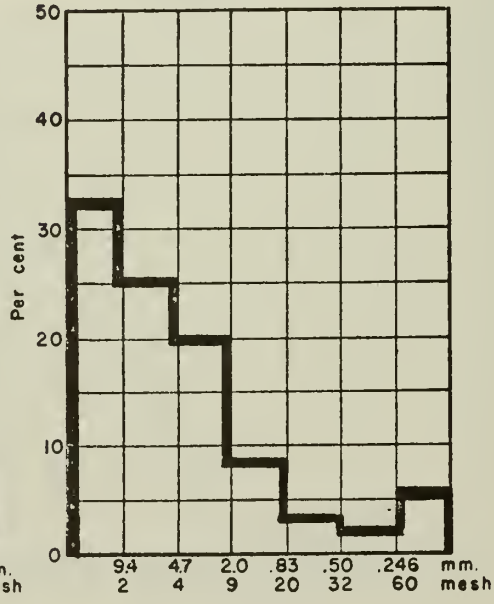
Sp C 6



Sp C 10



Sp C 18



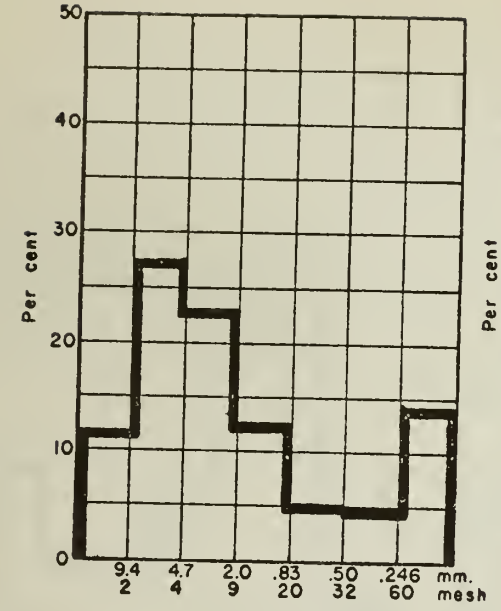
Sp C 25

Sp C 6 – 565' to 570'

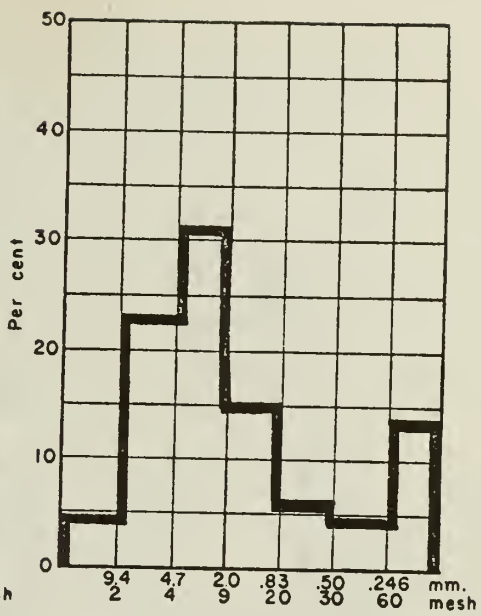
Sp C 10 – 545' to 550'

Sp C 18 – 505' to 500

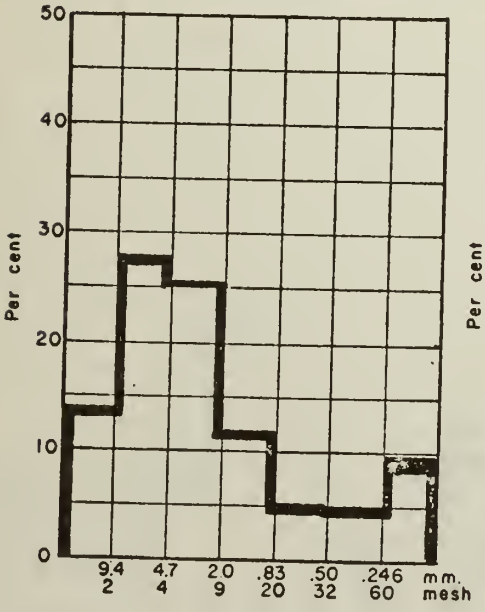
Sp C 25 – 460' to 465'



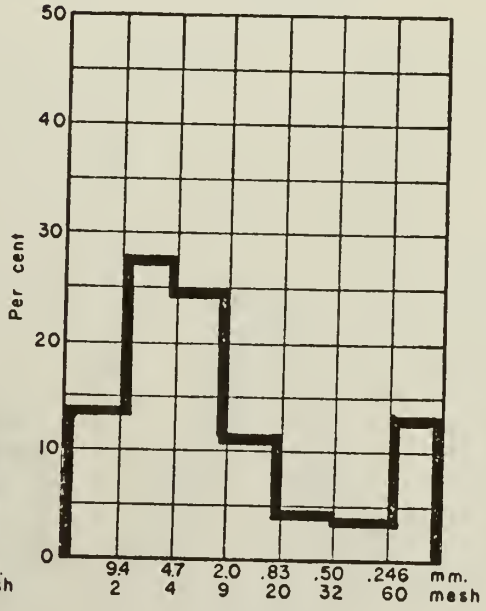
Sp C 32



Sp C 39



Sp C 43



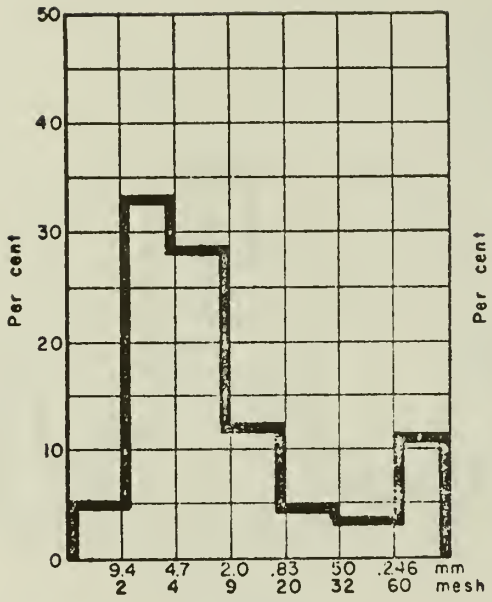
Sp C 48

Sp C 32 – 425' to 430'

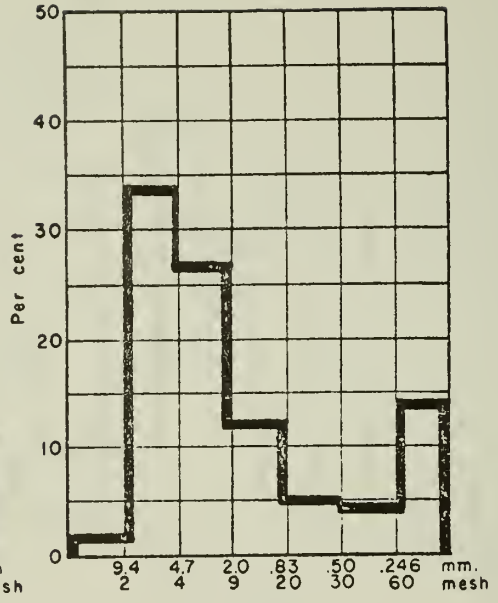
Sp C 39 – 390' to 395'

Sp C 43 – 295' to 300'

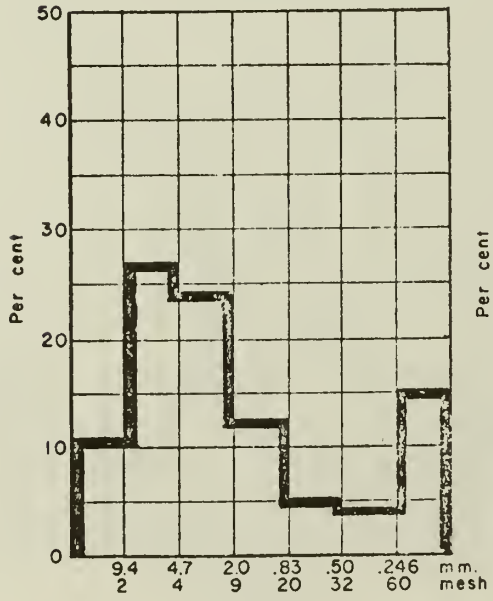
Sp C 48 – 270' to 275'



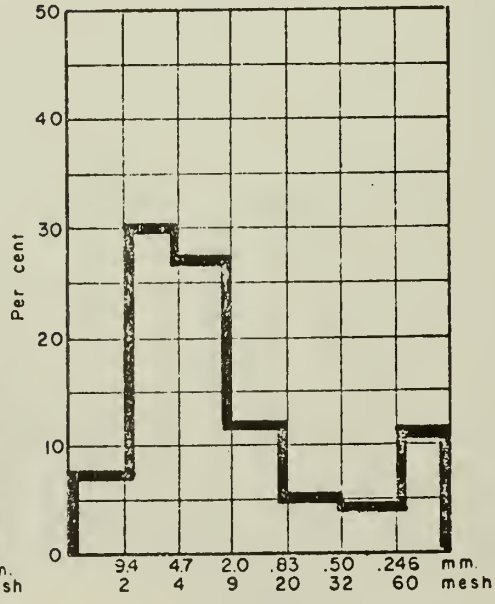
Sp C 52



Sp C 61



Sp C 66



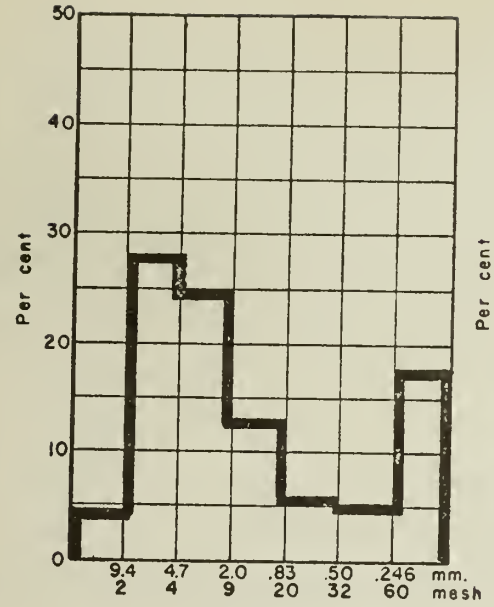
Sp C 73

Sp C 52 – 250' to 255'

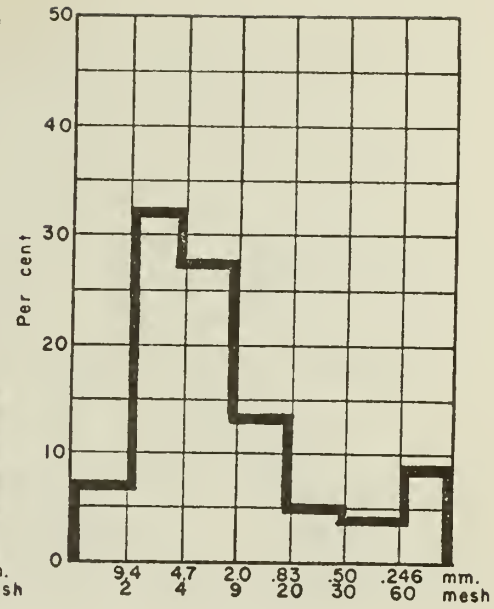
Sp C 61 – 205' to 210'

Sp C 66 – 180' to 185'

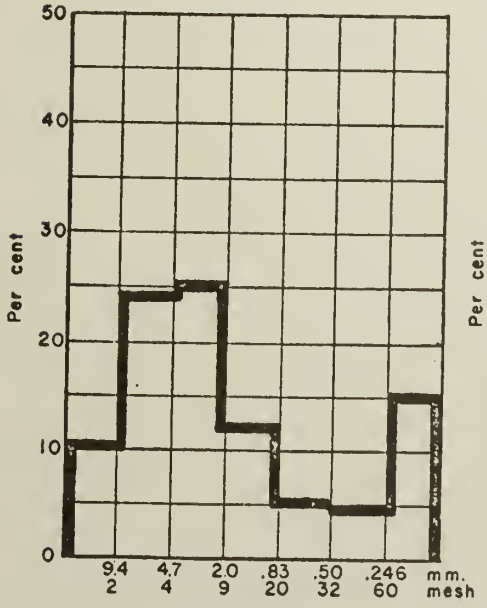
Sp C 73 – 145' to 150'



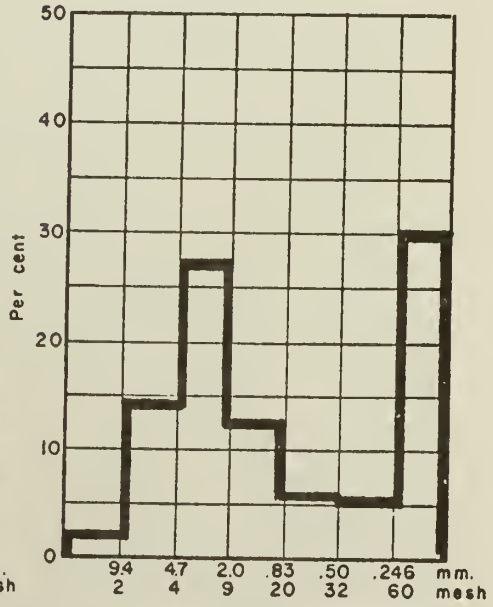
Sp C 81



Sp C 87



Sp C 92



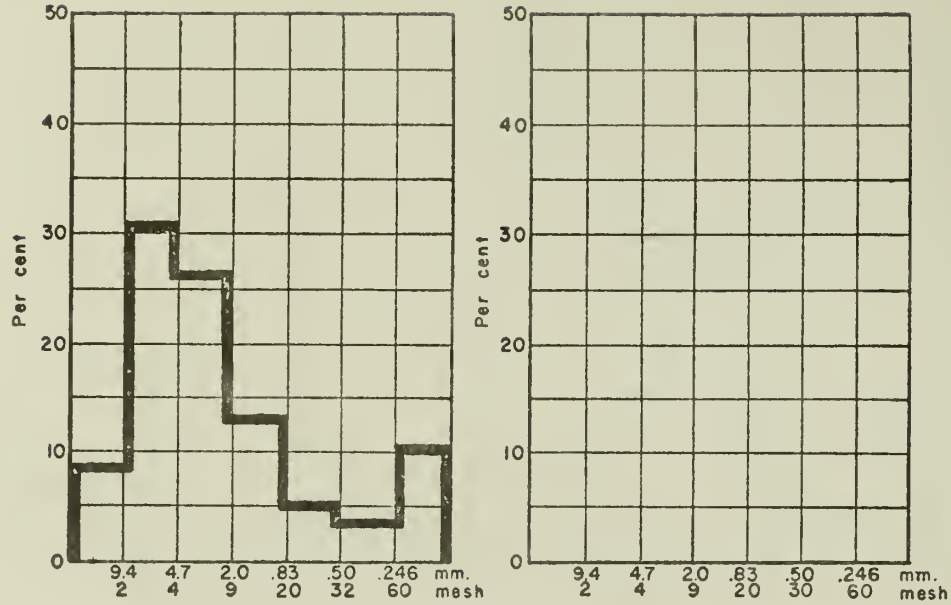
Sp C 96

Sp C 81 – 105' to 110'

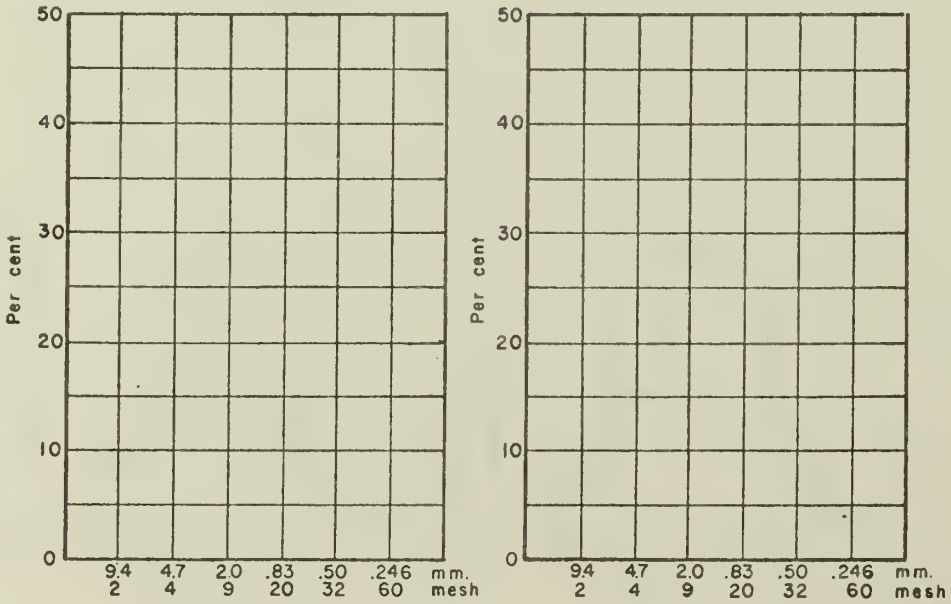
Sp C 87 – 75' to 80'

Sp C 92 – 50' to 55'

Sp C 96 – 30' to 35'

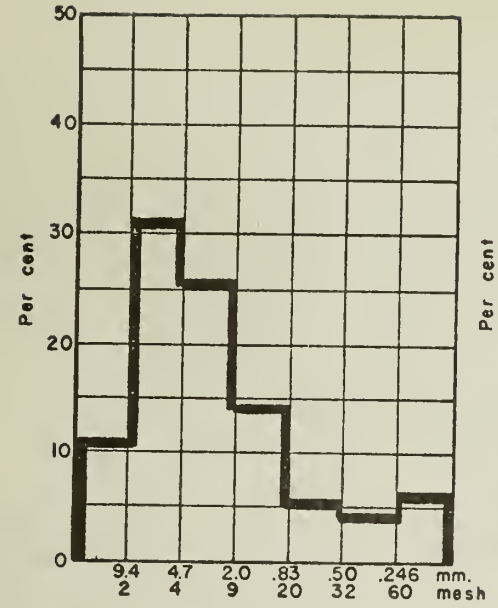


Sp C 102

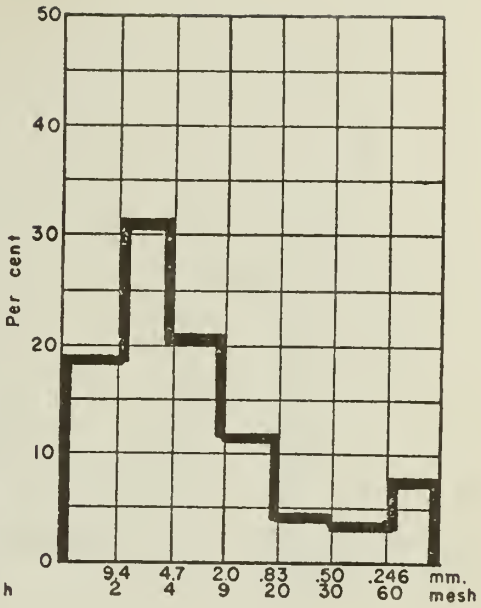


Sp C 102 – 0' to 5'

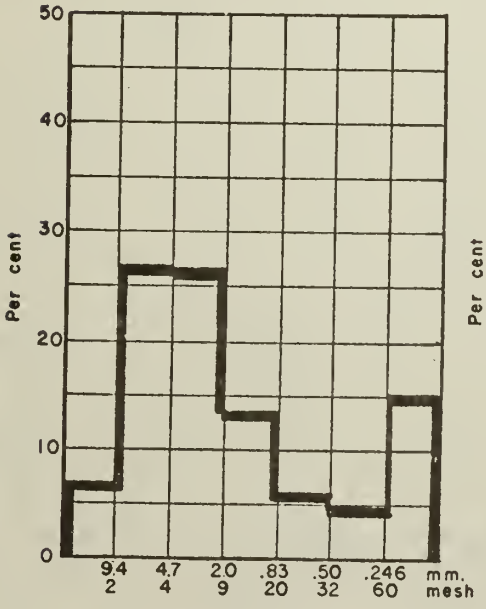
SPEARFISH CANYON - PAHASAPA



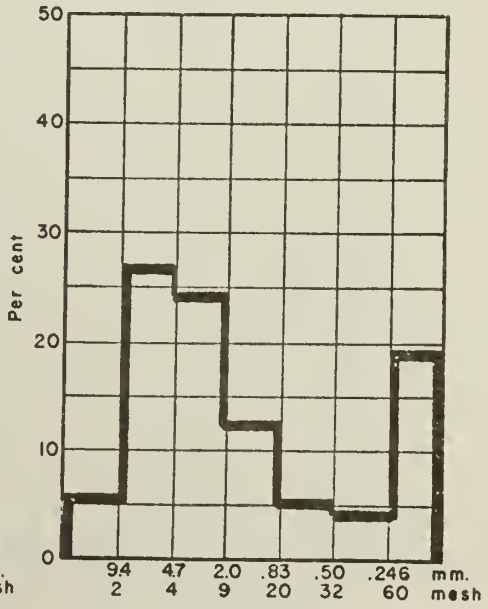
RR Ce l



RR 2



RR 5



RR 7

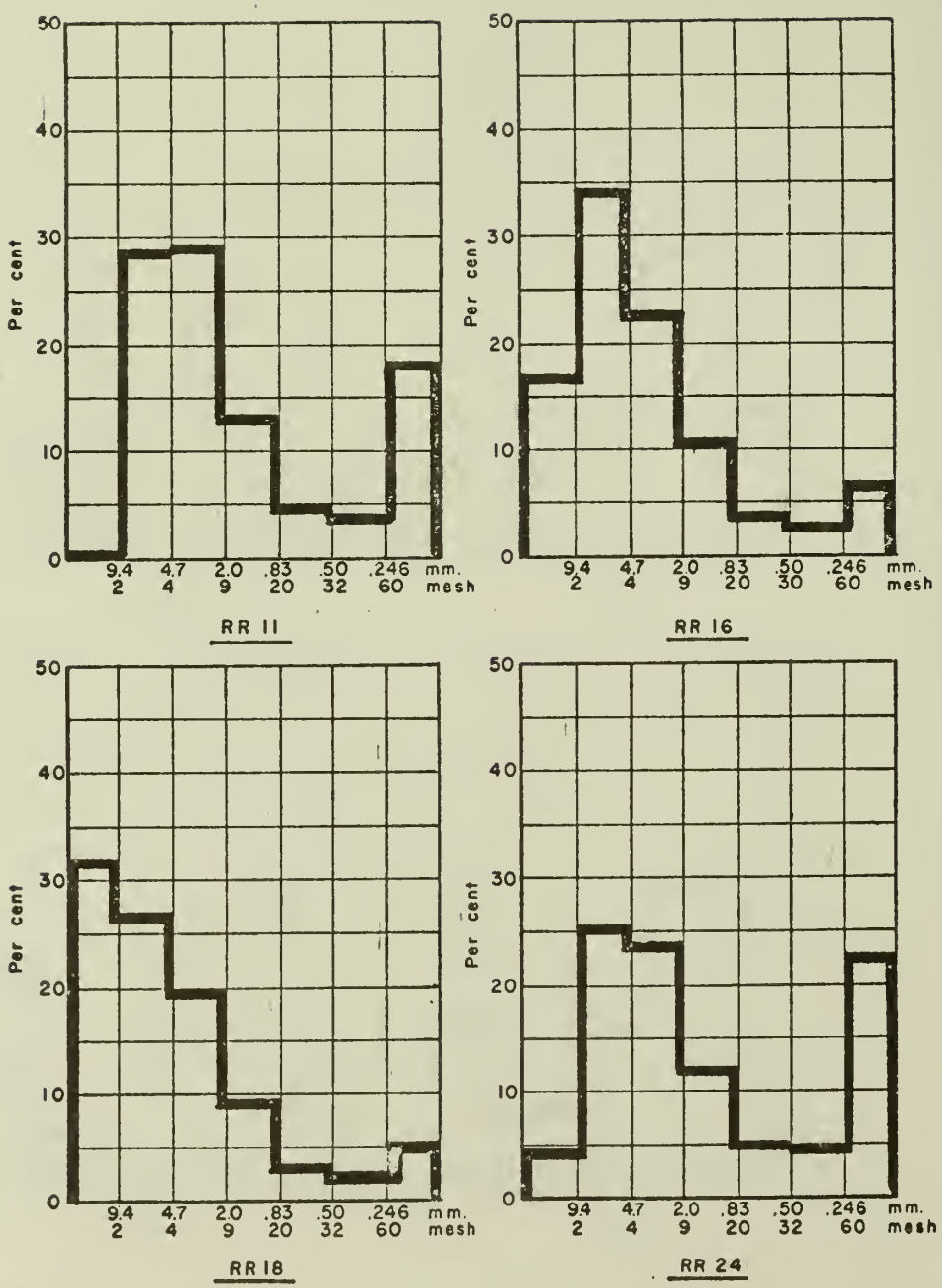
RR Ce l – 0' to -20

RR 2 – 0' to 5'

RR 5 – 15' to 20'

RR 7 – 25' to 30'

RHOADES RANCH - ENGLEWOOD & PAHASAPA

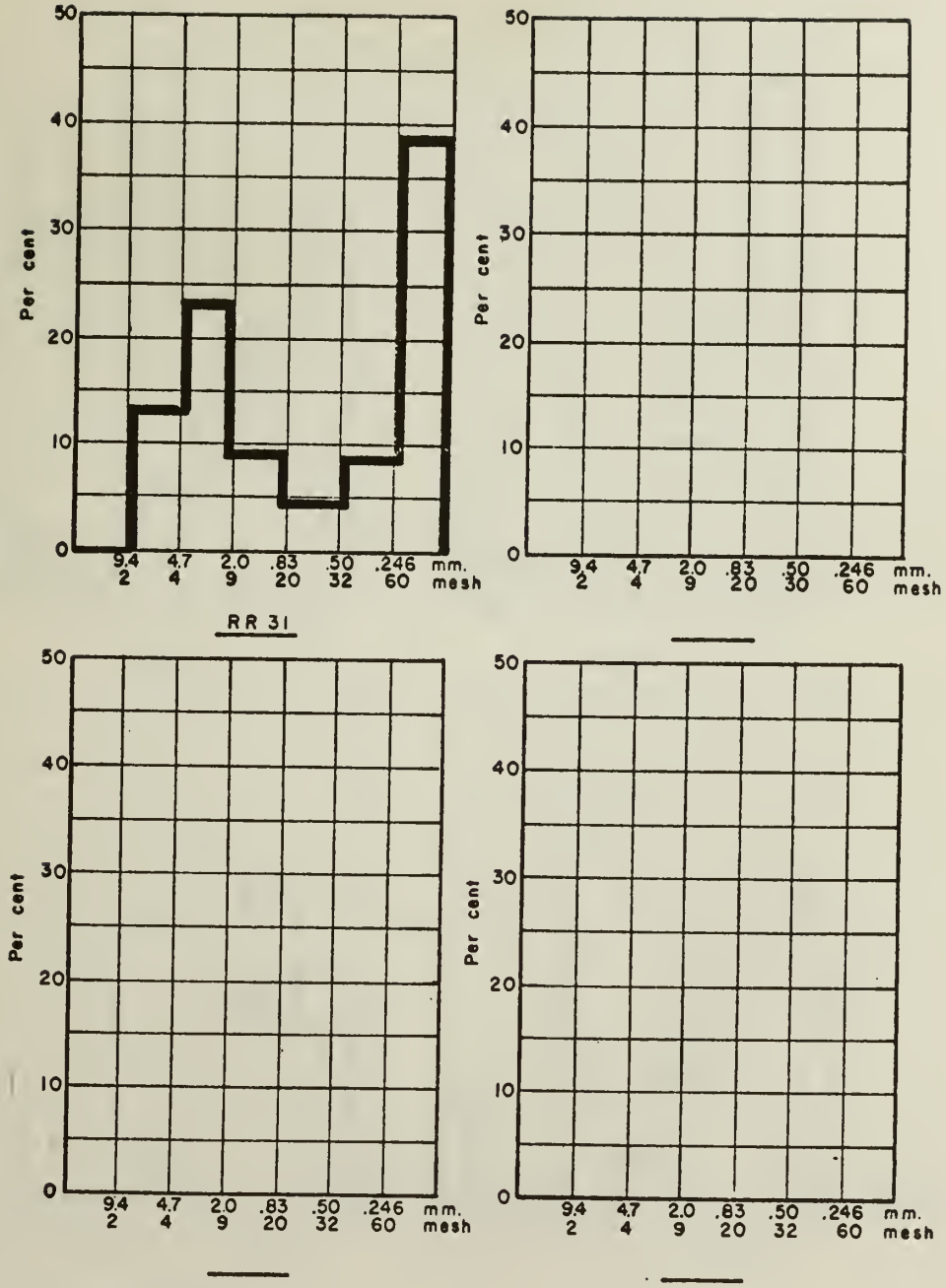


RR 11 - 45' to 50'

RR 16 - 70' to 75'

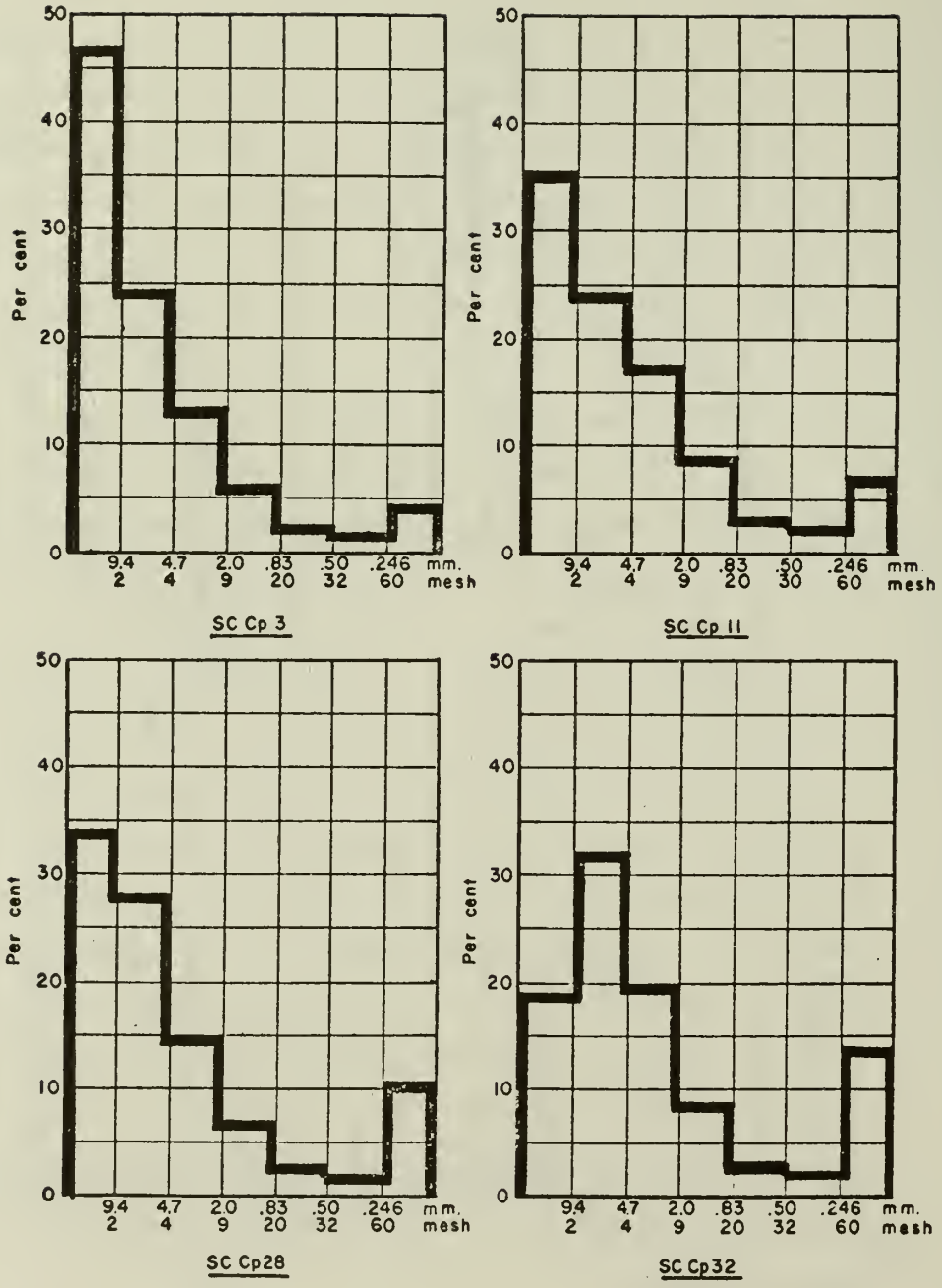
RR 18 - 80' to 85'

RR 24 - 170' to 175'



RR 31

RR 31 - 290' to 295'

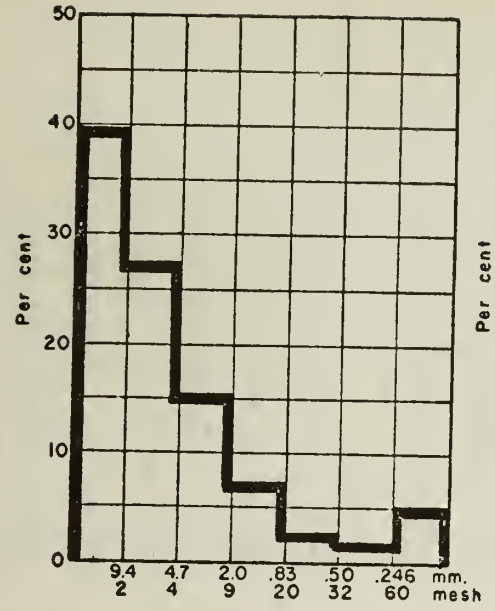


SC Cp 3 – 20' to 25'

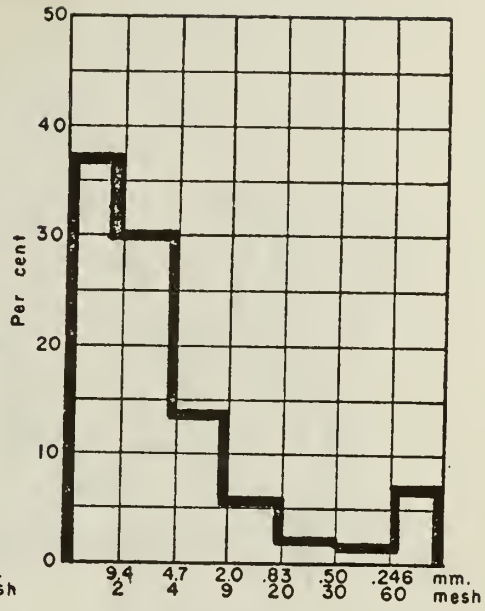
SC Cp11 – 60' to 65'

SC Cp28 – 165' to 170'

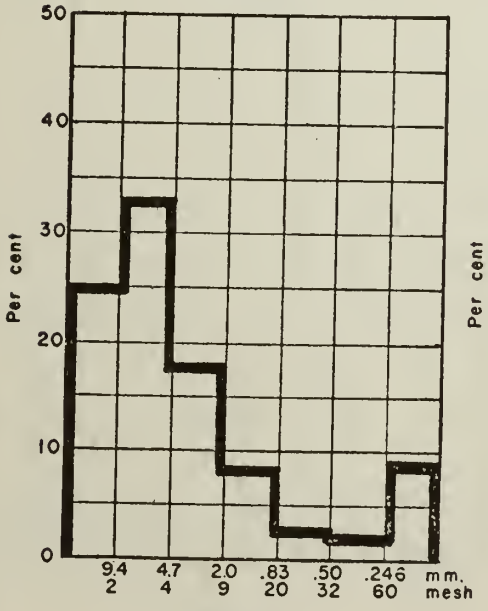
SC Cp32 – 185' to 190'



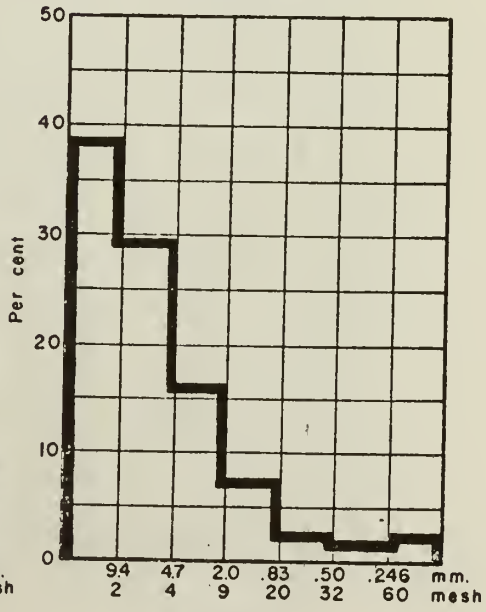
SC Cp 38



SC Cp 40



SC Cp 47



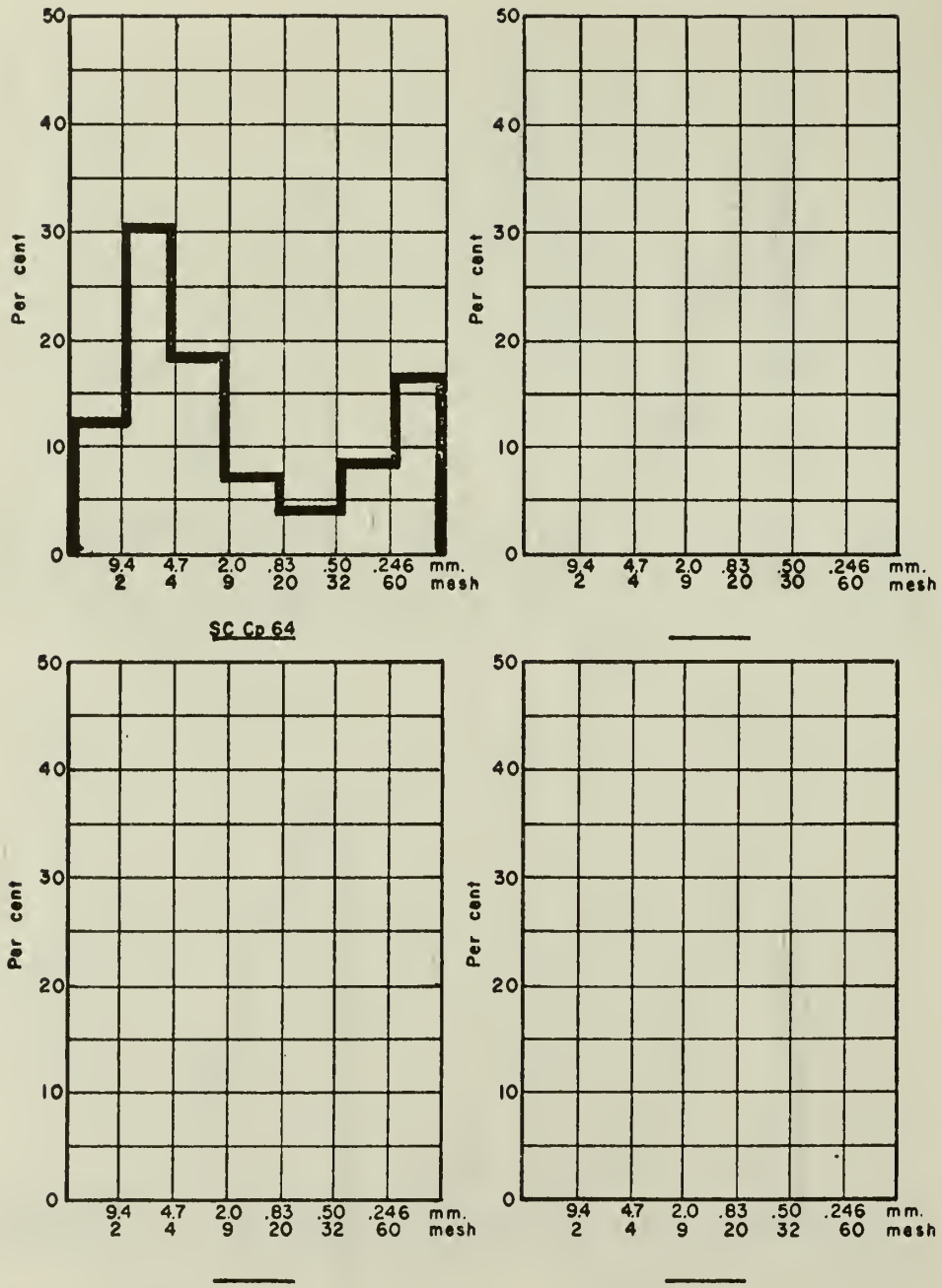
SC Cp56

SC Cp38 – 215' to 220'

SC Cp40 – 225' to 230'

SC Cp47 – 235' to 240'

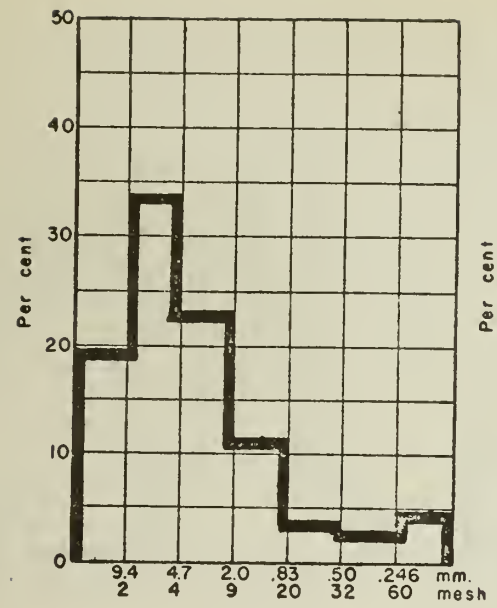
SC Cp56 – 380' to 385'



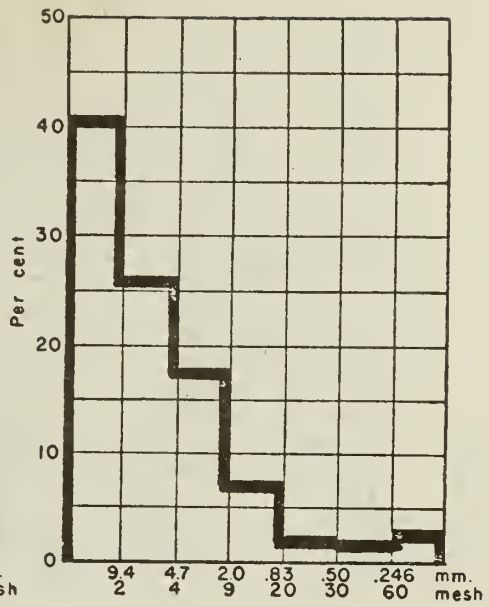
SC Cp 64

SC Cp 64 – 420' to 425'

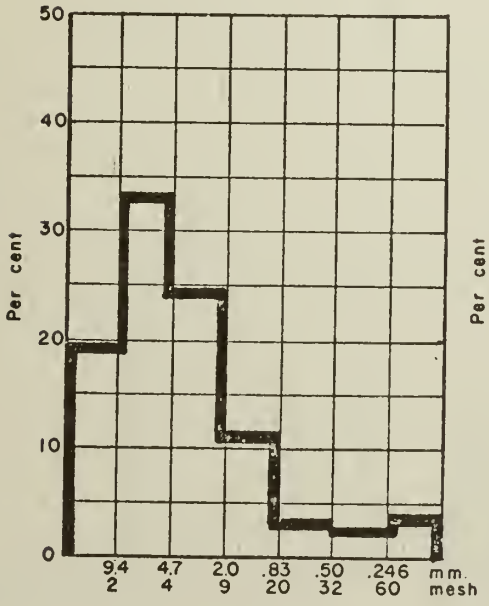
SPRING CREEK - PAHASAPA



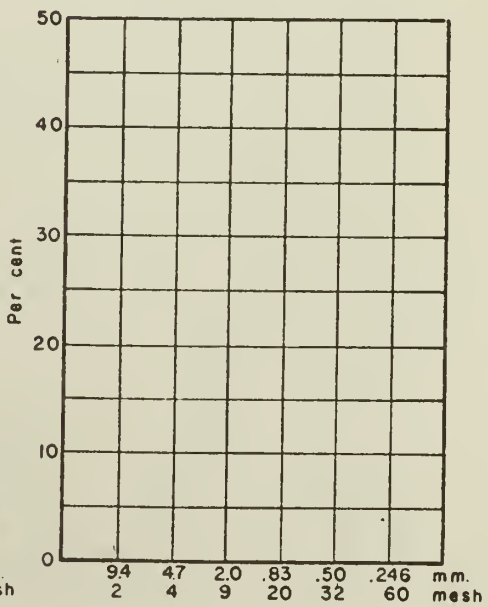
T-m 1A



T-m 2A



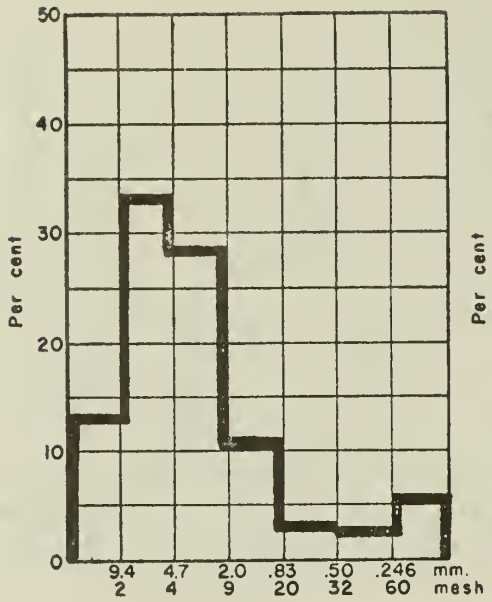
T-m 3A



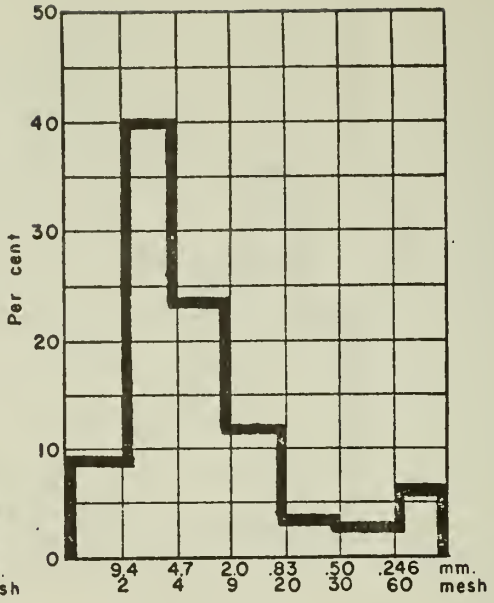
T-m 1A – Tymochtee quarry, Ohio.

T-m 2A – " " "

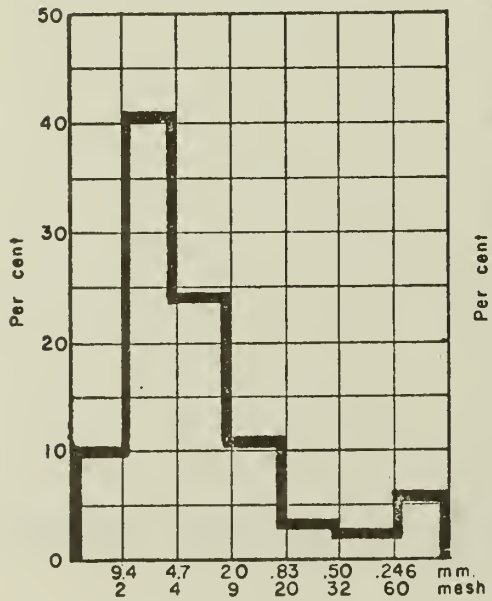
T-m 3A – " " "



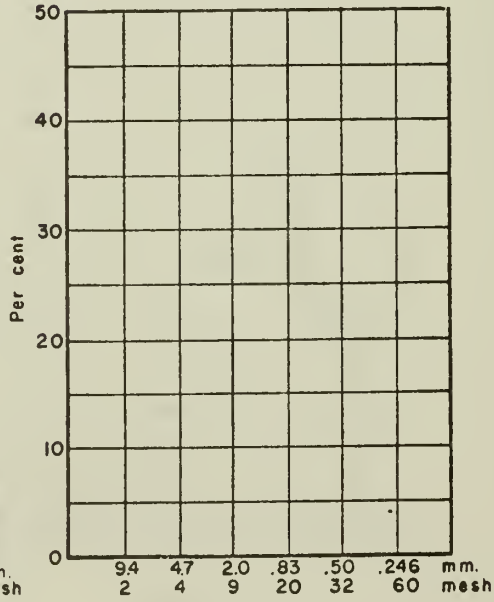
T-b 1A



T-b 2A



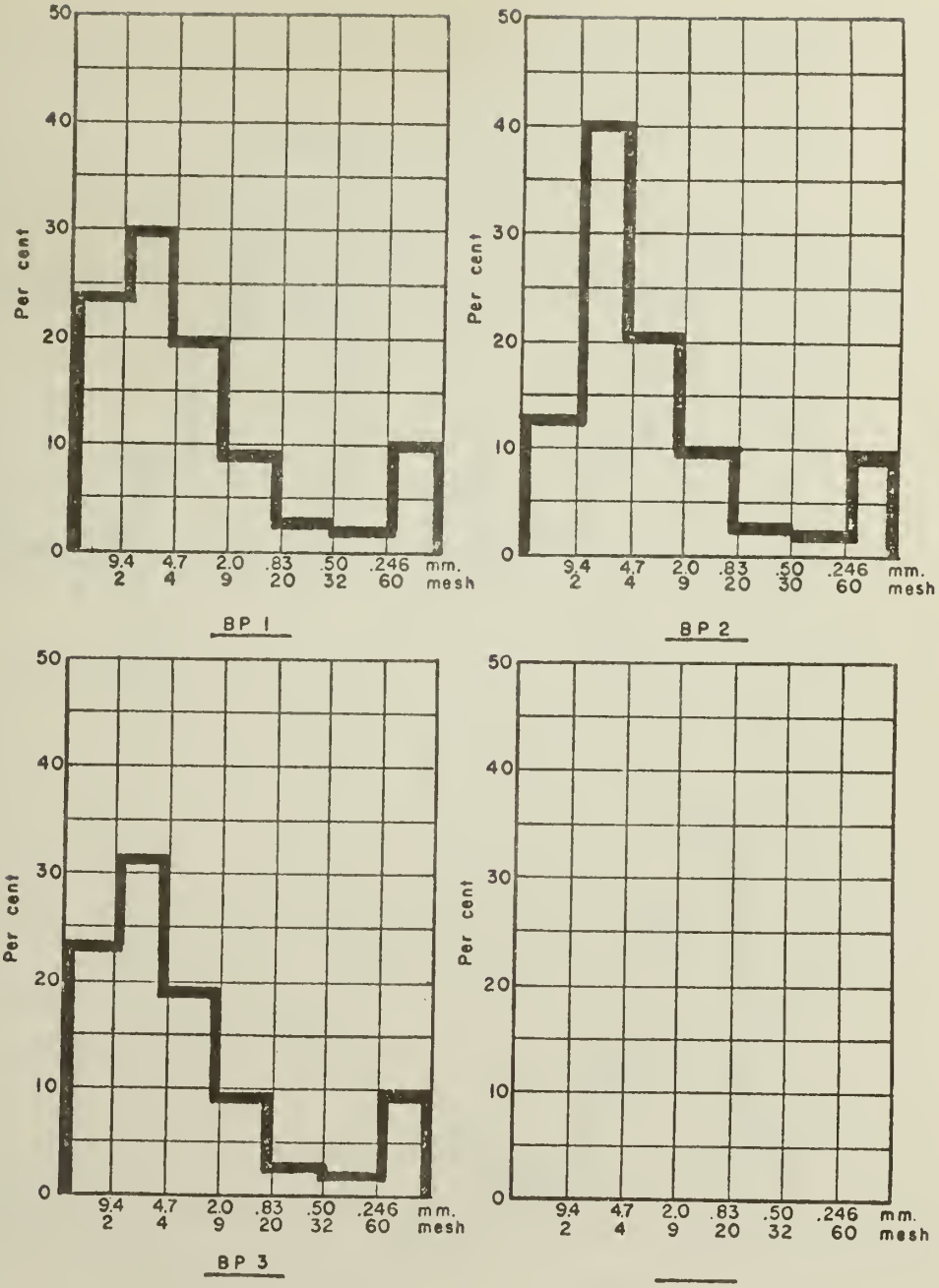
T-b 3A



T-b 1A - Tymochtee quarry, Ohio.

T-b 2A - " " "

T-b 3A - " " "

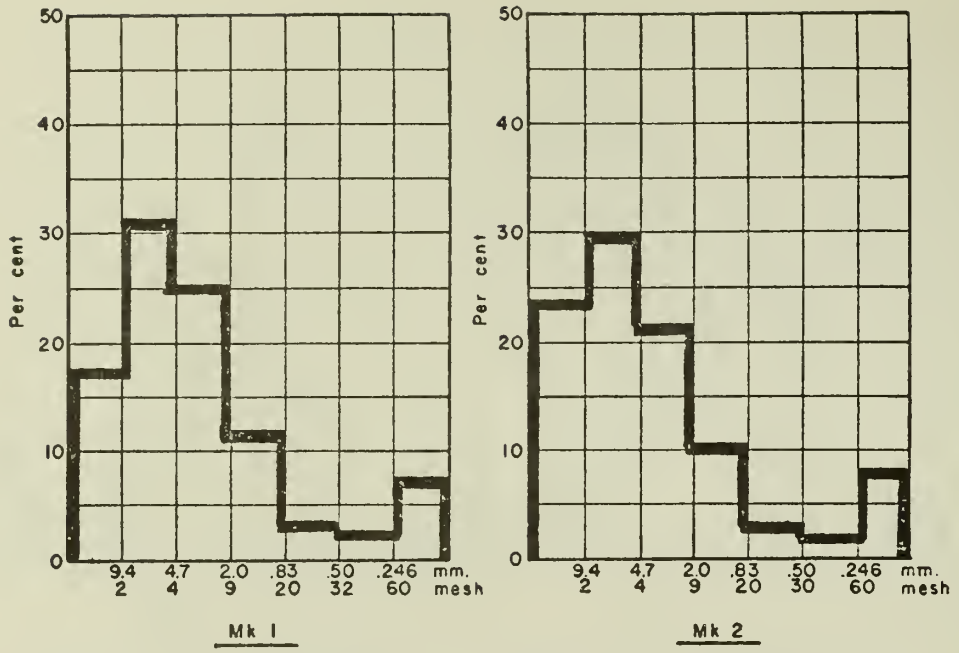


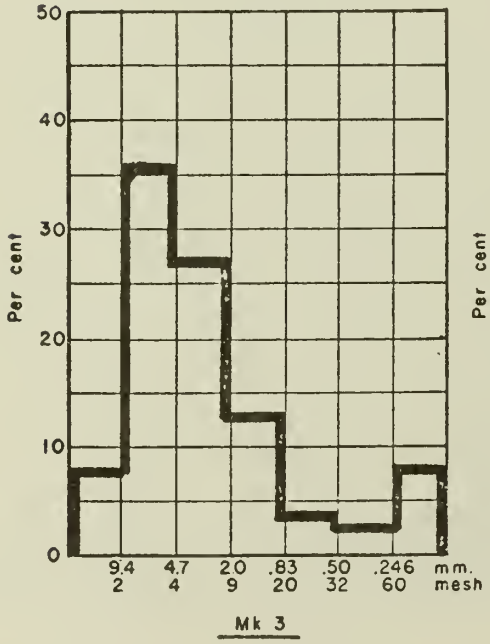
BP 1 – Hwy. 40 W.

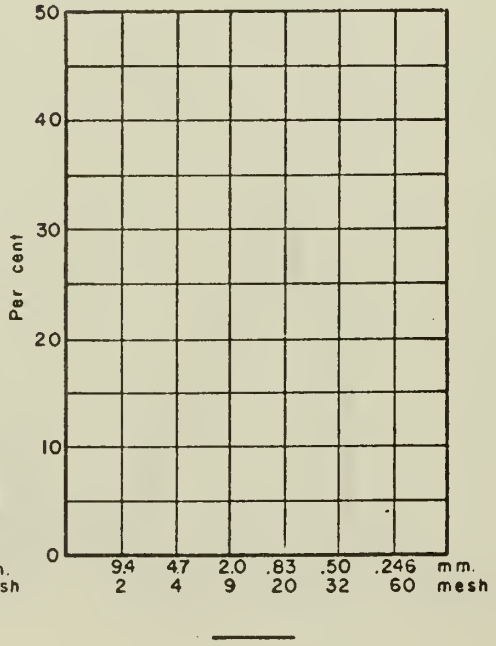
BP 2 – Hwy. 40 W

BP 3 – Hwy 40 W

BASAL PAHASAPA - HWY. 40 W.







Mk 1 – Hills Material Quarry

Mk 2 – " " "

Mk 3 – " " "

APPENDIX D

DETAILED SURFACE SECTIONS

The detailed surface section logs presented in this appendix are described in Subsection 5.2 in Book 1 of this volume.

Surface Section - Lodgepole

MISSION CANYON

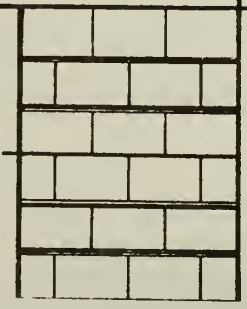
Blaine Co., Montana

Section 8, T26N, R24E

Vertical Scale: 1" = 5'

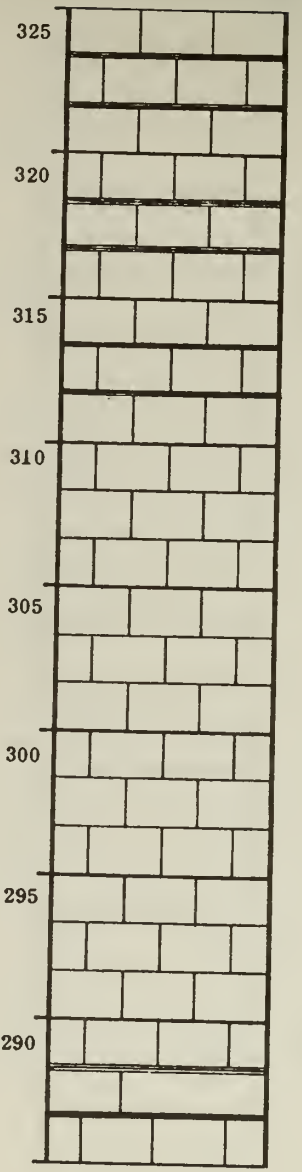
Dept. of Geol. & Geol. Eng., S.D.S.M. & T.

By: J.P.G., J.G., G.B.S.



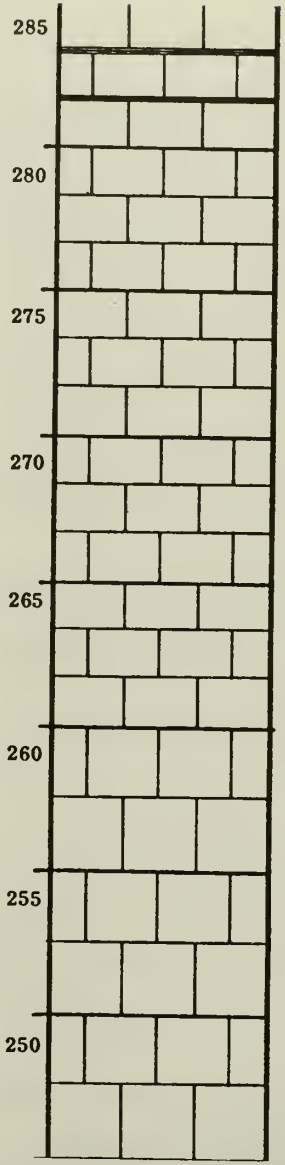
	% Dolo.	Grain Size	
			TOP LODGEPOLE
335	10	vfn.-mic.	Mlp 49: ls., gry. brn., mainly vfn.-crypt. xln., arg., w/ some crs. xln. biosparite in bands, shly. partings, some shears, massive, Fe stain.
330	10	vfn.-crs.	Mlp 48: ls., red-gry.-brn., mainly vfn.-crypt. xln., lam., arg. w/ shly. partings and some crs. xln. biosparite, brachs, etc., hematite stain.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 1 of 10)



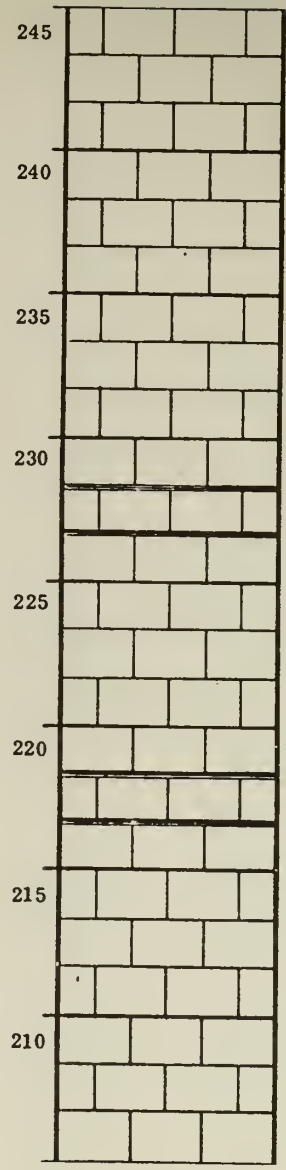
10	vfn.-crs.	Mlp 47: ls., purplish gry., vfn.-crs. xln. biosparite, recryst., arg., w/ some lam. vfn.-crypt. xln. arg., ls., occ. graded bedded calc. arenite.
10	vfn.-mic.	Mlp 46: ls., dark purplish gry., vfn.-crypt. xln., dense, litho., arg., some interbedded shly. ls., foss., lam?
10	vfn.-crs.	Mlp 45: ls., as 46 w/ some crs. xln. biosparite.
-	-	See 44.
10	vfn.-crs.	Mlp 44: ls., (purple brn. red), interbedded, vfn.-crypt. xln., arg., dense, litho., and crs. xln., arg., biosparite, some biosparite w/ vfn. xln. arg. matrix, corals, crinoids, brachs, shly. partings, sheared, beds 2-6", hematitic.
5	med.-crs.	Mlp 43: ls., tan gry., mainly med.-crs. xln. biosparite, some vfn. xln., calc. filled vugs, limon. stain, shears, crinoids, etc.
10	vfn.-crs.	Mlp 42: ls., similar to 44.
10	vfn.-mic.	Mlp 41: ls., gry. purple, vfn.-crypt. xln., dense, arg., sheared parallel to bedding, some sparry foss. brachs, shly. thin, interbeds.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 2 of 10)



285	10	vfn.-mic.	Mlp 40: ls., similar to 41, some healed vert. shears.
280	1-	vfn.-crs,	Mlp 39: ls., similar to 41, some crs. xln. biosparite, brecciated.
275	10	vfn.-mic.	Mlp 38: ls., dk. gry. brn., vfn.-crypt. xln., dense, sheared, blocky, arg., some Fe stain.
270	10	vfn.-crs.	Mlp 37: ls., as in 38 but including in some places 50% crs. xln., white, spar. replacing foss. ?
265	10	vfn.-mic.	Mlp 36: ls., gry. brn., vfn.-crypt. xln., arg., dense, thin shly. beds, beds 2-10".
260	10	vfn.-crs.	Mlp 35: ls., dk. gry. brn., vfn.-crypt. xln., dense, blocky, arg., some Fe stain, grading up to 50% crs. xln., white, biosparite, crinoids, brachs.,
255	5	med.-crs.	Mlp 34: ls., dk. gry., med.-crs. xln. biosparite, recryst., limonite, vuggy in part, sltly. arg., beds 12-18".
250	5	med-crs.	Mlp 33: ls., as 34, more sheared.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 3 of 10)



245	10	fn.-crs.
240	5	mic.-med.
235	10	vfn.-mic.
230	10	vfn.-crs.
225	10	vfn.
220	10	vfn.-mic.
215	5	vfn.-crs.
210	5	vfn.-crs.

Mlp 32: ls., dk. gry., grading from as 33 to fn. xln., w/ white spar. replacing brachs, sheared, some limonite.

Mlp 31: ls., dk. gry., mainly fn.-crypt. xln., dense, sltly. arg., blocky with occl. bands of lt. gry., med. xln., sparry.

Mlp 30: ls., dk. gry., vfn.-crypt. xln., dense, sltly. arg. blocky, 2-6" beds.

Mlp 29: ls., gry.-gry. brn., vfn. xln., dense, arg., w/ vfn. xln.-crs. xln. biosparite, some thin shly. beds.

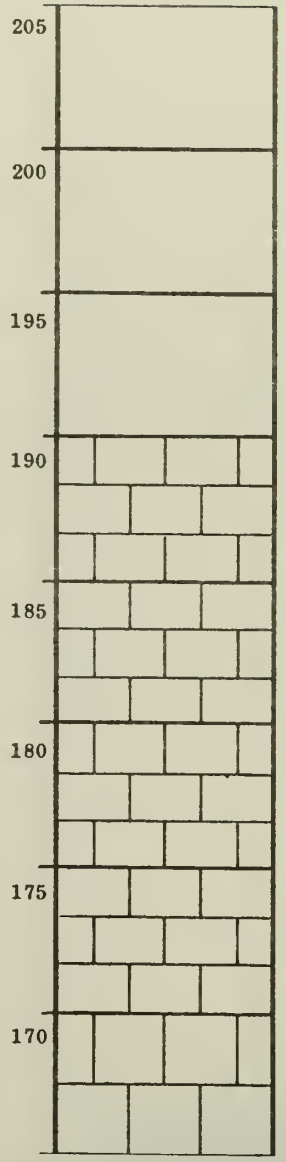
Mlp 28: ls., dk. gry., mainly vfn.-crypt. xln., sltly. arg., dense with occl. white sparry patches and replaced foss. brachs, crinoids.

Mlp 27: ls., dk. gry. brn., vfn.-crypt. xln., sltly. arg., dense, sheared, beds 2-6", shly. partings.

Mlp 26: ls., gry., vfn.-crypt. xln. w/ crs. xln. biospar. to 100% med.-crs. xln. biosparite, foss. hash, bryozoa, crinoids, brachs, milky white spar.

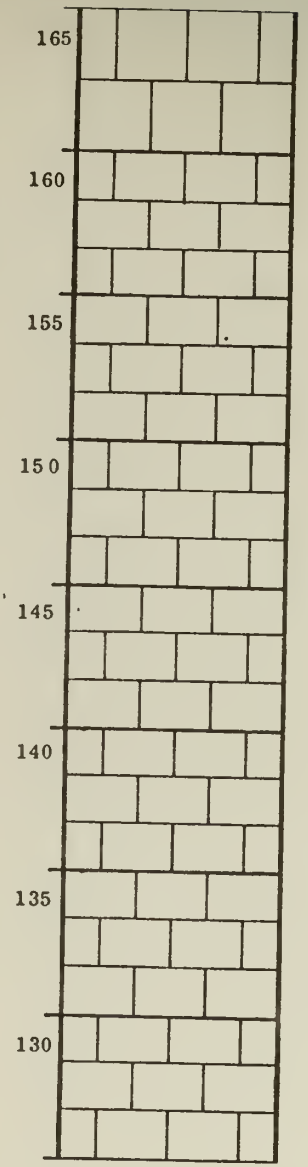
Mlp 25: ls., gry., vfn. xln., dense sltly. arg. to 80% crs. xln. biosparite, brachs, sheared.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 4 of 10)



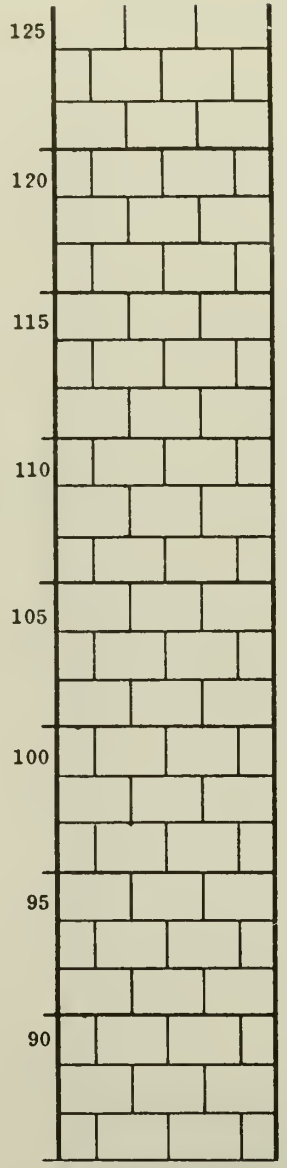
			Mainly covered.
			Mainly covered.
			Mainly covered.
10	vfn.-mic.		Mlp 24: ls., dk. gry., mainly vfn.-crypt. xln., brachs filled w/ calc., fracs. and vugs filled w/ calc. sltly. arg., dense.
10	vfn.-mic.		Mlp 33: ls., dk. gry., vfn.-crypt. xln., dense, sltly. arg., some shears.
			Same.
5	vfn.-mic.		Mlp 22: ls., gry., from vfn.-crypt. xln., dense, sltly. arg., to beds of clastic brach hash w/ vfn.-crypt. xln. matrix, some spar.
5	vfn.		Mlp 21: ls., gry. brn., mainly vfn. xln., recryst. biosparite some pellets, oolites?, some spar., brachs, sltly arg.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 5 of 10)



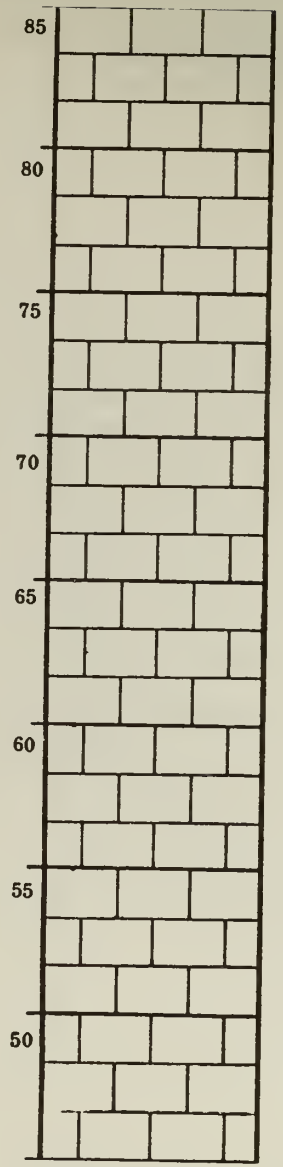
5	vfn.-mic.	Mlp 20: ls., dk. gry., vfn.-crypt. xln., fairly dense, sheared, weaths. buff, beds 18"-4'.
-	-	Same as 19.
10	vfn.	Mlp 19: ls., gry., brn., vfn. xln., sucrosic, w/ sparry patches, partly recryst. foss. hash, occl. white sparry foss., crinoids, arg.,
10	med.-crs.	Mlp 18: ls., gry. brn., med.-crs. xln., sparry, recryst. foss. hash, brachs, arg., limonite.
10	vfn.-mic.	Mlp 17: ls., gry. brn., vfn.-crypt. xln., thin bedded, excellent brachs, some lam. and contorted lam. w/ crinoids on lam. surface, arg. in part.
-	-	See 17:
10	vfn.-crs.	Mlp 16: ls., gry. brn., vfn.-crs. xln. clastic biosparite gastropods, corals, brachs, bryozoa, arg., slightly siliceous, some vfn.-crypt. xln. dense.
10	fn.-crs.	Mlp 15: ls., gry. brn., fn.-crs. xln., brach biosparite, fn. xln. matrix, 6-12" beds, few chert stringers.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 6 of 10)



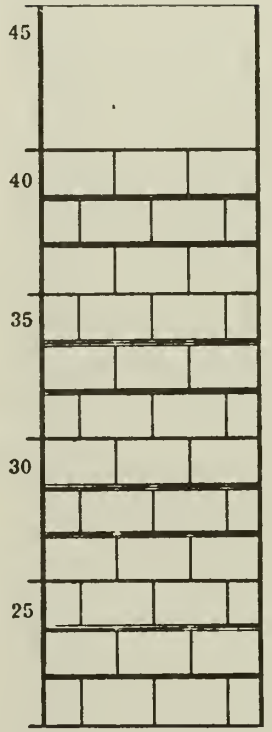
125	-	-	See 15.
120	10	vfn.-mic.	Mlp 14: ls., gry. brn., vfn.-crypt. xln., dense, arg., weaths. sucrosic.
115	-	-	see 14.
110	10	fvn.-mic.	Mlp 13: ls., gry. brn., vfn.-crypt. xln., dense, arg., blocky, weaths. sucrosic, foss?
105	10	fn. crs.	Mlp 12: ls., gry. brn., fn. & crs. xln., biosparite, w/ small brachs, fn. xln. matrix, partly silicificd, foss. hash, interbed w/ vfn.-crypt. xln., dense, sltly siliceous.
100	-	-	See 12.
95	-	-	See 12.
90	10	vfn.-crs.	Mlp 11: ls., dk. gry., interbedded, crs. xln. biosparite w/ vfn.-crypt. xln. matrix, brachs, crinoids, and vfn.-crypt. xln., dense, sltly. arg., sheared & healed.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 7 of 10)



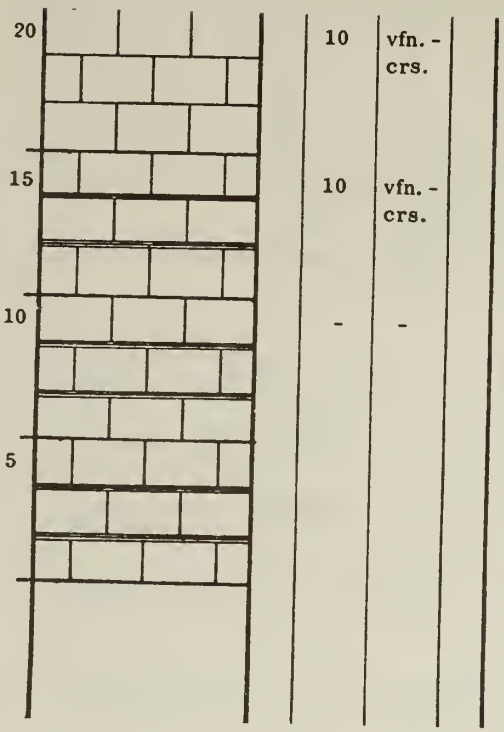
85	-	-	See above.
80	10	vfn.-crs.	Mlp 10: ls., gry., fn.-vfn. xln. w/ veins of crs. xln. spar., some limey tan shale interbeds.
75	-	-	See 10. Interbeds of crs. and fn. xln. dense ls.
70	-	-	See 10.
65	10	fn.-crs.	Mlp 9: ls., gry.-brn., fn.-crs. xln. sparite, w/ some foss. hash, limonite, some arg.
60	10	vfn.-crs.	Mlp 8: ls., gry., vfn.-crs. xln. sparry, recryst., brachs, interbed w/ dk. gry., vfn.-crypt. xln. dense, litho., ls., beds 3" to 4', shly. partings, fracs. perpendicular to beds.
55	10	vfn.-crs.	Mlp 7: ls., similar to 8.
50	10	vfn.-mic.	Mlp 6: ls., dk. gry., vfn.-crypt. xln., some white spar., dense, fracs, brachs.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 8 of 10)



45	-	-	Covered.
40	-	-	See 5.
35	10	vfn.-crs.	Mlp 5: ls., gry. fn.-crs. xln. sparry, foss., limonite interbed w/ ls., dk. gry., vfn.-crypt. xln., dense, sheared, good brachs, beds 2-12", 1-2" shly partings.
30	10	vfn.-crs.	Mlp 4: similar to 5.
25	-	-	See 5.

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 9 of 10)



10	vfn.-crs.	Mlp 3: ls., dk. gry., vfn.-crypt. xln., dense, litho., interbeds of crs. xln. sparry.
10	vfn.-crs.	Mlp 2: similar to 3, brachs, beds 1"-1', thin shly partings, spar. in joints & fracs.
-	-	See 2.
		Mlp 1: ls., gry., vfn.-crs. xln. sparry, brachs, bryozoa, interbeds vfn. xln., lam., arg., partings

MISSION CANYON SECTION, LODGEPOLE TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 10 of 10)

Surface Section – Mission Canyon Type

MISSION CANYON

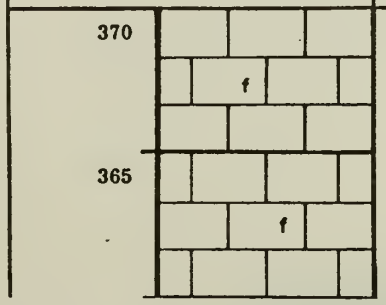
Blaine County, Montana

Section 8, T26N, R24E,

Vertical Scale: 1" = 5'

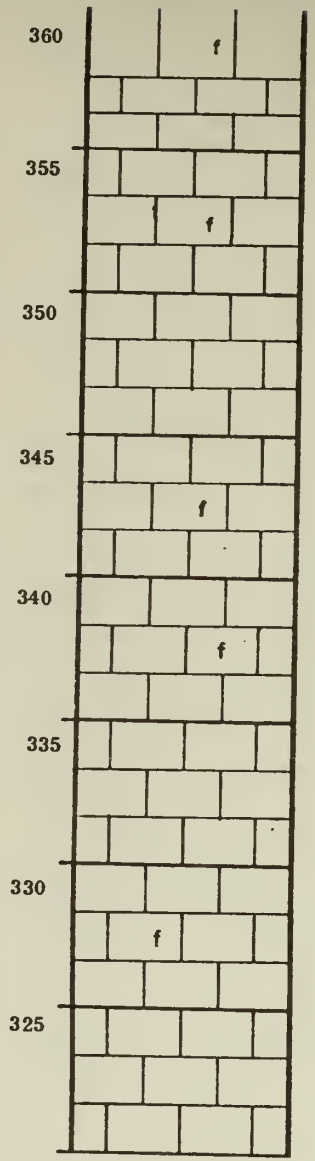
Dept. of Geol. & Geol. Eng., S.D.S.M. & T. 7/71

By: J.P.G., J.G., G.B.S.



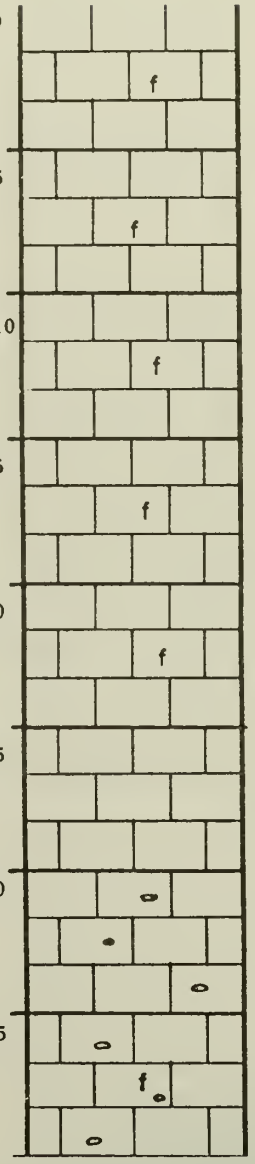
	% Dolo.	Grain Size	
370	10	vfn.-crs.	Mmc 74: ls., buff-gry., crs. xln. biosparite, crinoids, brachs, some recryst. fn.-vfn. w/ spar.
365	10	vfn.	Mmc 73: ls., lt. gry., biopellsparite, recryst. to vfn. xln., foss., crinoids, spicules.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 1 of 10)



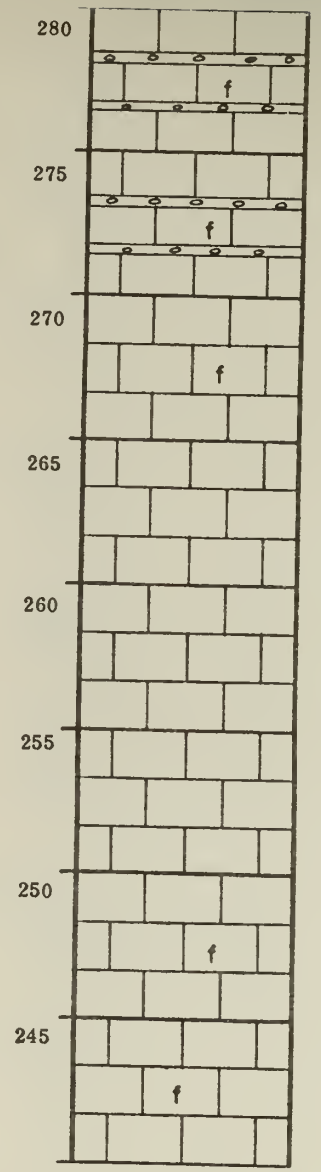
10	fn.-crs.	Mmc 72: Ls., gry. w/ pink strks., biopellsparite, fn.-crs. xln., brachs, stylolites, chert, echinoids, beds 6"-2'.
10	vfn.-mic.	Mmc 71: ls., gry., vfn.-crypt. xln. w/ spar. syringapora, slickensides, chert.
10	vfn.-mic.	Mmc 70: ls., lt. gry., vfn.-crypt. xln., recryst. pelletal.
10	crs.-mic.	Mmc 69: ls., lt. gry., varies from crypt. xln. to pellsparite, brachs, crinoids, some pink-orange to tan mottling, sheared.
10	crs.	Mmc 68: ls., pink-gry., biopellsparite, brachs, crinoids, echinoids, Fe stain, sheared, some vfn.-crypt xln. w/ spar.
10	mic.	Mmc 67: ls., gry.-pink, crypt. xln., dense, lithographic.
10	vfn.-crs.	Mmc 66: ls., lt. gry., biopellsparite, sparry, crinoids, brachs, vfn.-crs. xln.
10	mic.	Mmc 65: ls., gry.-pink, crypt. xln. recryst. pelletal, dense.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 2 of 10)



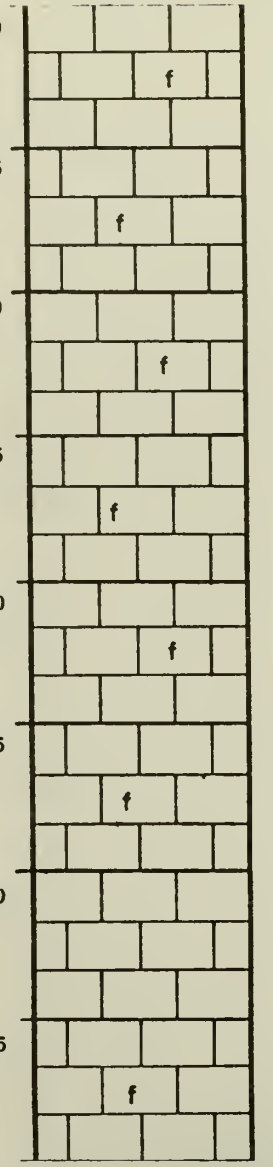
10	crs.	Mmc. 64: ls. , gry. -lt. tan, pellsparite, crinoids and brachs.
10	vfn.	Mmc 63: ls., gry., biopellsparite, vfn. xln. w/ spar., looks crs. xln., crinoids, brachs, some hematite.
10	vfn.	Mmc 62: ls., gry. w/ tan cast, vfn. -crypt. xln. recryst. biosparite, looks crse.
10	vfn. - mic.	Mmc 61: ls., buff, vfn. -crypt. xln., banded w/ pink orange, small black pellets-mang., small spar. patches, recryst. pelletal.
5	vfn. - crs.	Mmc 60: ls., mottled yel. -tan and light purple, vfn. xln. with patches crs. spar. replacing foss., brachs., crinoids, recryst., occl. calc. filled vug, few hematite spots.
10	vfn. - mic.	Mmc 59: ls., buff gry., vfn. -crypt. xln. w/ occl. spar, sheared.
5	vfn. - mic.	Mmc 58: ls., light gry., vfn. -crypt. xln., dense, sheared scattered chert nods.
5	mic- crs.	Mmc 57: ls., light gry., mainly vfn. -crypt. xln., dense, recryst. pelletal-foss., some, patches crs. xln. spar., small blebs hematite, sheared, some chert.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 3 of 10)



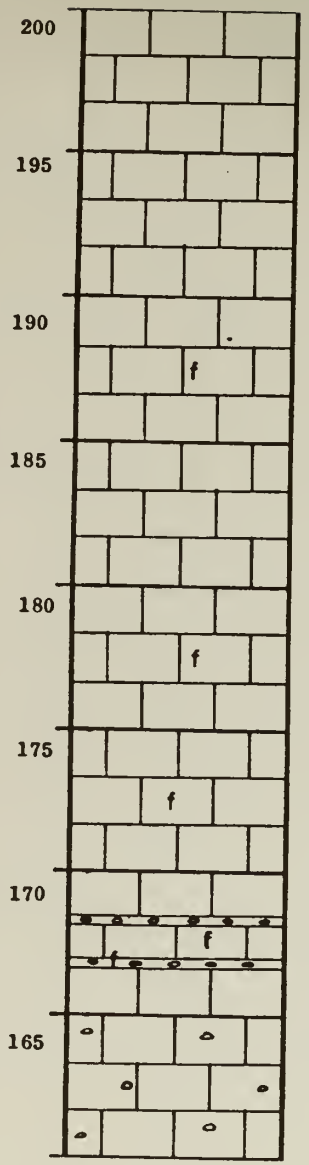
15	vfn.	Mmc 56: ls., buff-gry., mainly vfn.-crypt. xln., recryst. foss.-pelletal, with some brach, crinoid foss. hash, gry. chert stringers 1" thick, some siliceous ls., sheared-brecciated.
10	vfn.-mic.	Mmc 55: ls., buff-yel. tan, vfn.-crypt. xln., chert-jasper lenses & nodules, brachs, sheared.
10	med.-crs.	Mmc 54: ls., buff-gry, pellsparite, med.-crs. xln. appearance, coral-rugose, bryozoa, some silicification, sheared.
10	--	Mmc 53: ls., buff-pink, crs. clastic with sparry cement, sheared.
10	vfn.-mic.	Mmc 52: ls., gry., vfn.-crypt. xln. with sparry white clasts, some pellets, recryst.
10	vfn.-mic.	Mmc 51: ls., gry.-light brn., vfn.-crypt. xln. w/ large clasts and small pellets recryst.
10	vfn.-crs.	Mmc 50: ls., light gry., vfn.-crs. xln., sparry calcite, crinoids, sheared.
10	vfn.-crs.	Mmc 49: ls., white, vfn.-crs. xln., crs. sparry xls., foss. hash, crinoids, oolites?, white sparry calcite replacing fossils.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 4 of 10)



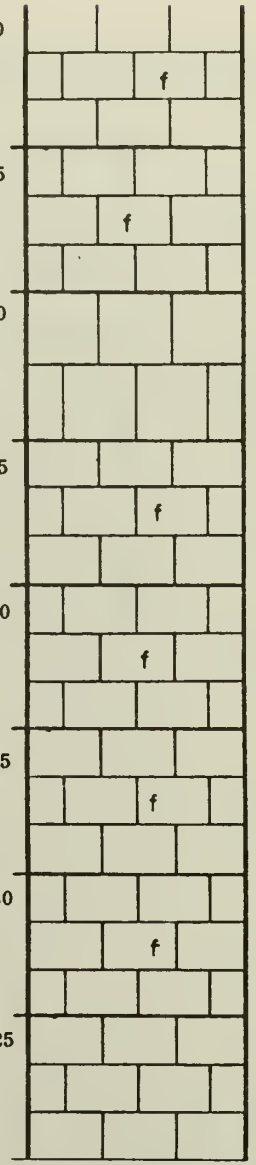
5	vfn.-crs.	Mmc 48: ls., white, vfn.-crs. xln., pelletal, oolites?, crinoids, sheared, recryst.
5	vfn.-crs.	Mmc 47: ls., white with gry., fn.-crs. xln., sparite, foss. hash, pellets, recryst.
10	vfn.-crs.	Mmc 46: ls., gry.-brn. med.-crs. xln., fn. pelletal, crinoids brachs, Fe stain.
10	crs.	Mmc 45: ls., buff, pellsparite, crs. xln., crinoids, Fe stain.
10	crs.	Mmc 44: ls., gry.-tan, pellsparite w/ few clasts, crs. xln., crinoids, sheared, some areas vfn.-crypt. xln., Fe stain.
10	crs.	Mmc 43: ls., gry.-tan, pellsparite, crs. xln., recryst. foss. relics, crinoids brachs, sheared.
10	vfn.-crs.	Mmc 43: ls., white, vfn.-crs. xln., recryst. pelletal? sheared.
10	fn.-med.	Mmc 41: ls., gry.-tan, pellsparite, fn.-med. xln., recryst., crinoids, brachs-spirifer, sheared.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 5 of 10)



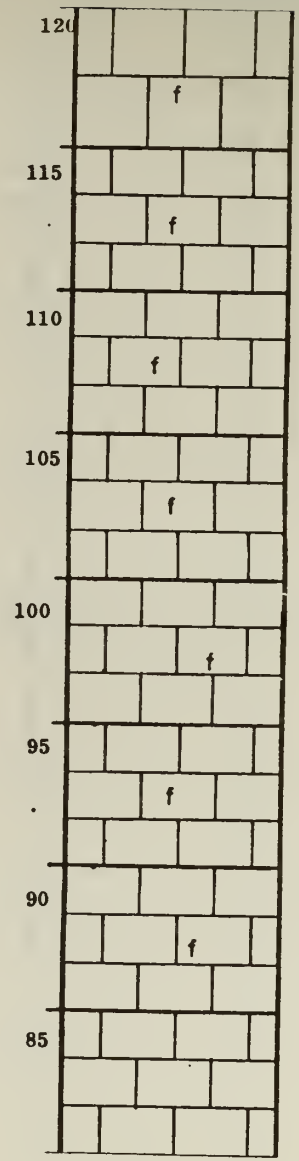
5	vfn.-crs.	Mmc 40: ls., white with pink, vfn.-crs. xln. sparry, recryst. pelletal?, sheared.
5	vfn.-crs.	Mmc 39: ls., same as 40.
5	crs.	Mmc 38: ls., white, crs. xln. sparry, recryst., sheared Fe stain, recryst. crinoids & pellets.
5	fn.-crs.	Mmc 37: ls., wh.-pink, pellsparite, bimodal fn. to crs., recryst.
5	fn.-med.	Mmc 36: ls., white, fn.-med. xln. sparite, crinoids, sheared.
5	fn.-med.	Mmc 35: ls., similar to 36 w/ Fe strks. on bedding, recryst. vfn. pelletal.
10	vfn.-mic.	Mmc 34: ls., lt.-gry., vfn.-crypt. xln., dense w/ brn. gry. chert lenses 2-6" w/ brachs, corals.
5	med.-fn.	Mmc 33: ls., lt. gry., med.-fn., recryst. sparite, sltly. fn. pelletal, hematite stain, sheared, chert nods up to 4" dia.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 6 of 10)



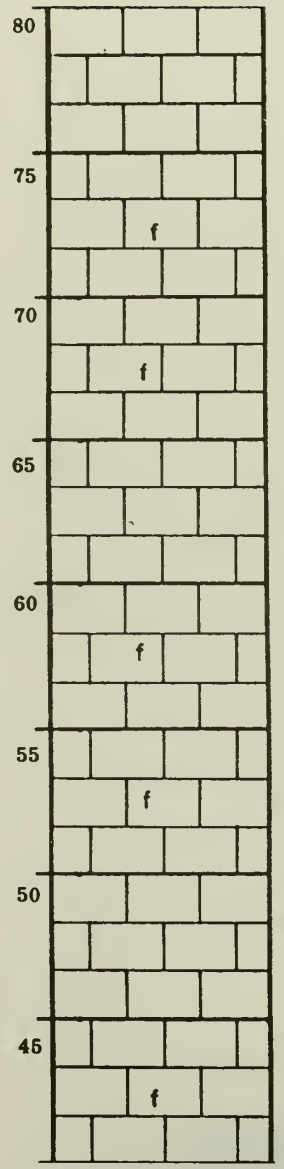
10	med.	Mmc 32: ls., buff gry., med. xln., sparry, fn. foss. hash, recryst. micrite.
10	med.	Mmc 31: ls., tan gry., med. xln. sparite, recryst. fn. pelletal, brachs, crinoids, chert nods, few foss. layers.
5	fn.	Mmc 30: ls., lt. gry., fn. xln. w/ occl. crs. calc. laths, recryst. pelletal, sparry massive beds, cavernous, weaths. buff.
10	fn.-vfn.	Mmc 29: ls., pink, fn.-vfn. xln. sucrosic, crs. white spar. inclusions, crinoids,
10	med.-crs.	Mmc 28: ls., gry., mod.-crs. xln., pelletal trashy fn., foss.
10	med.	Mmc 27: ls., gry. tan, med. xln., vfn. pelletal hash.
15	fn.	Mmc 26: ls., lt. gry., fn. xln. sucrosic w/ med. xln. sparry incl. or foss. molds, weaths. gry.
5	fn.-med.	Mmc 25: ls., light pink brn., fn.-med. xln., sparry patches, hematite strks., calc. veins, weaths. gry.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 7 of 10)



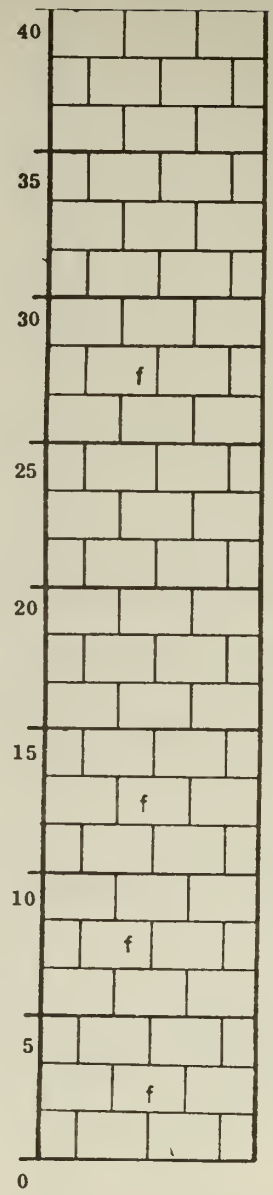
10	vfn.-med.	Mmc 24: ls., pinkish gry., vfn.-med. xln., inter xln. por., uniform, massive beds, few brachs, weaths. gry. buff.
5	vfn.-med.	Mmc 23: ls., white, vfn.-med. xln., recryst. biopelletal sparry, crinoids, brachs, massive, weaths. buff.
10	med.	Mmc 22: ls., light gry. brn., med. xln., recryst. biopelletal, brachs abnt., crinoids, sheared.
10	med.-crs.	Mmc 21: ls., light gry., med.-crs. xln., trashy fn. biopelletal, massive, calc. veins, weaths. yel.-buff gry.
15	mic.	Mmc 20: ls., dk. gry. brn., micrite, healed fracs., lithographic, interbed w/ lt. gry. tan, med. xln., pelletal biosparite, brach, some shears.
10	vfn.-crs.	Mmc 19: ls., gry-brn., vfn. xln. & crs. xln. sparry calc. vy. foss., crinoids, bryozoa, brachs, echinoids, biopellsparite.
10	fn.-med.	Mmc 18: ls., gry.-brn., fn.-med. xln., biopellsparite, many trashy foss., some vfn.-crypt. xln. dense.
10	vfn.	Mmc 17: ls., gry. brn., vfn. xln., dense, 1-6" beds lithographic, sheared.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 8 of 10)



10	vfn.	Mmc 16: ls., gry. brn., vfn. sucrosic - lithographic, sltly. arg.
10	vfn. - med.	Mmc 15: ls., gry. brn., vfn.-med. xln. sparite w/ calcite lathes, sucrosic in part, limonite specks recryst. clastic? Sparry foss. molds crinoids.
10	vfn. - mic.	Mmc 14: ls., dk. gry., vfn.-crypt., dense, lithographic interbed with crs. xln. biosparite, brachs, crinoids w/ micrite matrix some shly. partings.
10	vfn. - mic.	Mmc 13: ls., brn.-gry., vfn.-crypt. xln., lithographic, arg., hematite stain.
10	vfn. - mic.	Mmc 12: ls., gry., vfn.-crypt. xln., dense, lithographic w/ occl. sparry calcite blebs poss. foss. molds, sheared beds 1-6".
10	med. - crs.	Mmc 11: ls., gry. brn., med.-crs. xln., biosparite— foss. hash, beds 8"-10".
10	vfn. - mic.	Mmc 10: ls., brn., vfn.-crypt. xln., lithographic arg. beds 2-10", sheared, shly. interbeds.
10	crs.	Mmc 9: ls., gry.-brn., crs. xln., biosparite, hematite stain, some foss. shale.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 9 of 10)



10	med.	Mmc 8: ls., gry. brn.-red brn., med. xln. biosparite, arg.
10	vfn.	Mmc 7: ls., gry. buff, vfn. xln., micrite foss.
10	fn. med.	Mmc 6: ls., gry. brn. tan, fn.-med. xln., arg., biohash foss. debris crinoid, brnch, light yellow brn. clay pellets.
10	vfn.-mic.	Mmc 5: ls., gry. brn., vfn.-crypt. xln., lithographic, dense, arg. sheared.
10	vfn.-mic.	Mmc 5: ls., gry. brn., vfn.-crypt. xln., lithographic, dense, arg. sheared.
10	med.-crs.	Mmc 3: ls., tan, med.-crs. xln., partly recryst. biosparite brachs, crinoids, shly. partings to 6", lam., beds 1-8".
10	vfn.	Mmc 2: ls., gry., vfn. xln. w/ sparry inclusions, sheared foss., shly, partings.
10	crs.	Mmc 1: ls., pinkish brn., crs. xln., biosparite, "sub coquinoid" bryozoa, brachs, 2-10" beds, shly. partings, clay pellets.

MISSION CANYON SECTION, MISSION CANYON TYPE LIMESTONE, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 10 of 10)

Surface Section (Madison Group)

BROWN'S CANYON

Blaine County, Montana

Section in 11 & 14, T.26N., R.24E.

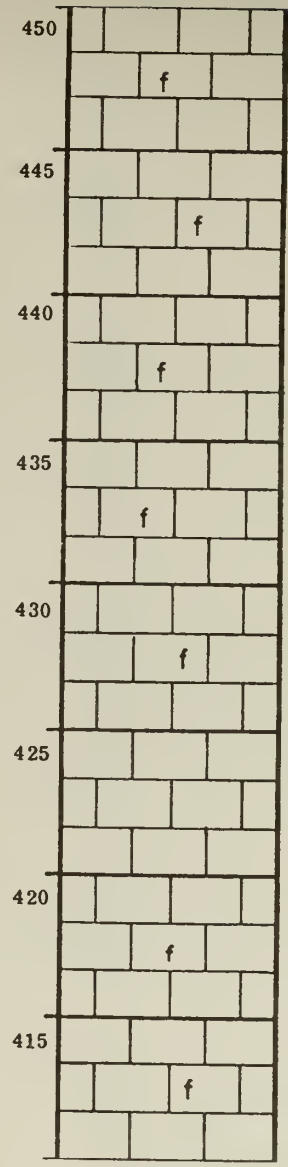
Vertical Scale, = 1 inch to 5 feet

Dept. of Geol. & Geol. Eng., S.D.S.M. & T., 7/71

By J.C.M., J.G., G.B.S.

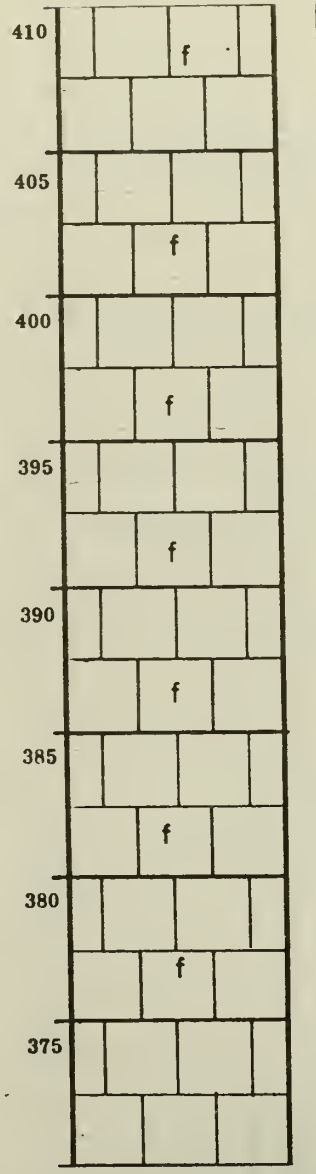
		% Dolo.	Grain Size	
460		15		MISSION CANYON Mmc 1: ls., lt. gry., crypt. crs. xln., pelletal frac-brecciated, sparry, foss. brachs & horn coral, beds 6"-3', jointed.
455		15		Mmc 2: ls., whitish gry., similar to above, lumps, pellets foss. hash?

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 1 of 13)



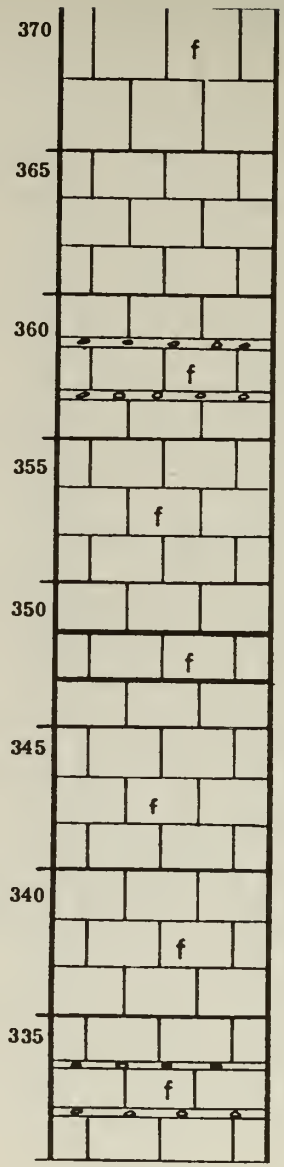
15		Mmc 3: ls., lt. gry., similar to above, lumps?, clastic. quite weathered, crinoids.
15		Mmc 4: ls., lt. gry.-pinkish org., vfn.-crs. sln., clastic, ± 1 mm. white crypt. xln. calcite clasts, spar., foss?
15		Mmc 5: ls., tan gry., similar to 4, crinoids, sheared, has coarse lam. appear.
15		Mmc 6: ls., lt. gry., similar to 4, foss.-recryst. crinoids, frac. w/ calc. recem., pink mottling.
15		Mmc 7: ls., lt. gry., similar to 4, sheared, stylolites.
10	vfn-micro	Mmc 8: ls., buff gry., mainly vfn.-crypt. xln., sparry patches, sheared, clasts, recryst.
15	fn.-crs.	Mmc 9: ls., buff, fn.-crs. xln., w/, sparry patches, clastic, crinoids, sheared, recryst.
15	vfn.-mic	Mmc 10: ls., gry.-tan, mainly vfn.-crypt. xln., w/ sparry patches, crinoid pinules.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 2 of 13)



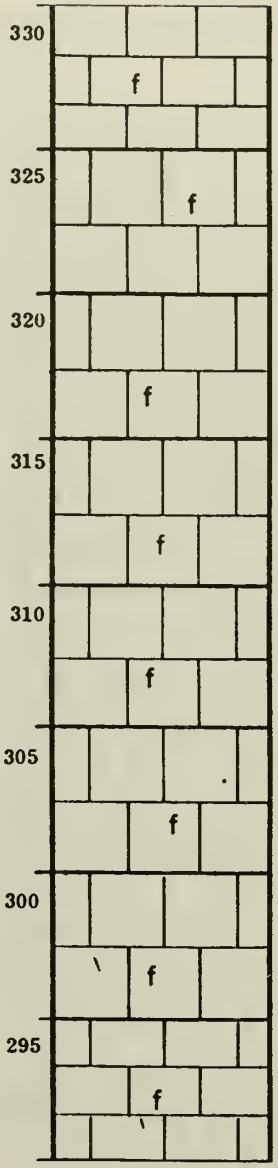
15		Mmc 11: ls., whitish buff, crinoidal hash, clastic, sparry in parts, stylolites, chert chunks in top 6".
20	vfn.-mic.	Mmc 12: ls., gry. buff, vfn.-crypt. xln., occl. crinoid column, stylolites, sltly. arg., some spar., sheared parallel to bedding, massive.
20	mic.	Mmc 13: ls., lt. gry. tan, crypt. xln., frac. fills w/ calc., dense, foss. brach-crinoids, scattered 1" chert stringers, stylolites, slty, clastic in places, mass.
20	mic.	Mmc 14: ls., lt. gry., crypt. xln., dense, similar to 13.
30	vfn.	Mmc 15: ls., lt. pinkish gry., vfn. xln., occl. spar. prob. foss., chert nodules, blocky frac.
25	vfn.-mic.	Mmc 16: ls., buff, gry., vfn.-crypt. xln., sheared-brecciated, sltly arg., foss., some.
15	vfn.	Mmc 17: ls., lt. gry., mainly vfn. xln., w/ areas of spar. calc. blebs and foss. molds, brachs, crinoids, Mn dend.
15	vfn.-mic.	Mmc 18: ls., lt. gry., vfn.-crypt. xln., sheared, hackly frac.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 3 of 13)



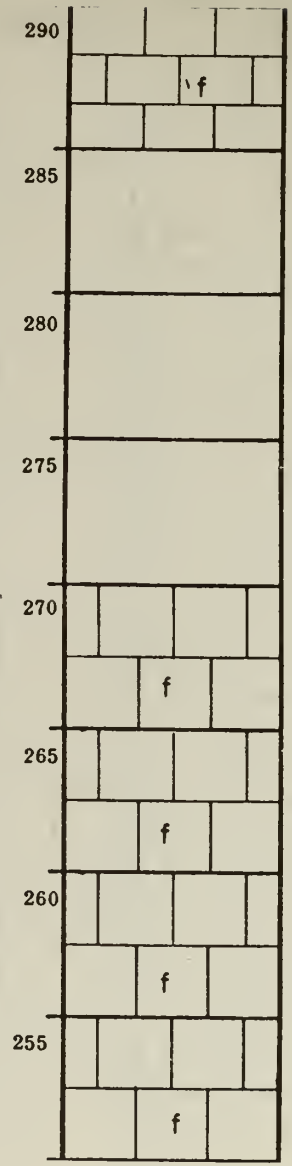
15	vfn	Mmc 19: ls., buff gry., vfn. xln., w/ wh. calcite blebs and foss. molds, sparry.
20	vfn.	Mmc 20: ls., mottled buff-gry.-pink, vfn. xln., recryst., w/ white calc. blebs, sparry, pelletal?
25	fn	Mmc 21: ls., buff gry., fn. xln., calc. blebs ± 1 mm. crinoids. W/ porcelainus chert, banded wh. & gry. chert secondary.
15	vfn.-mic.	Mmc 22: ls., buff gry., vfn.-crypt xln., sheared weathered, brecciated, Fe stain, foss. relicts.
20	fn	Mmc 23: ls., yel-buff, fn. xln., spongey-punky weath., foss. crinoids-brachs, sparry calc. blebs & strks. slty. arg.
15	vfn	Mmc 24: ls., buff gry., vfn.-crypt. xln. w/ occl. wh. calc. blebs and pellets, foss., sparry patches, beds 6-18".
20	vfn.	Mmc 25: ls., buff, vfn.-crypt. xln., color mottling, some clasts or pellets, brachs.
20	vfn.	Mmc 26: ls., buff-gry., vfn. xln., sheared, chert stringers, foss.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 4 of 13)



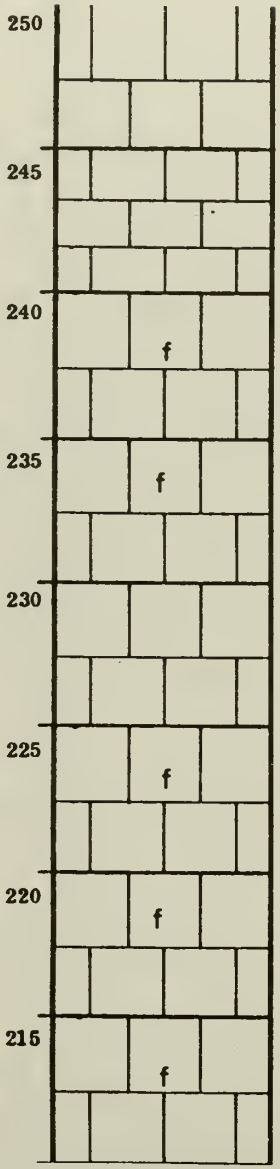
15	vfn.	Mmc 27: ls., buff gry., vfn. xln. w large sparry patches, foss., beds 6-10".
15	vfn.	Mmc 28: ls., lt. gry., vfn. xln. w large sparry patches, foss. crinoids, sheared occl. chert, massive.
15	vfn.	Mmc 29: ls., buff-pinkish, vfn. xln. w/ sparry patches and calc. blebs, crinoids, sheared.
10		Mmc 30: ls., lt. gry.-whitish, clastic-crinoidal, brachs, corals, stylolites, recryst., vy sparry, massive.
10		Mmc 31: ls., buff-gry., similar to 30, some shears.
15		Mmc 32: ls., buff, similar to 30.
10		Mmc 33: ls., whitish buff, similar to 30, some recryst. to vfn.-med. xln.
10		Mmc 34: ls., buff, similar to 30 but more recryst., Fe stain, sheared with slicken sides.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 5 of 13)



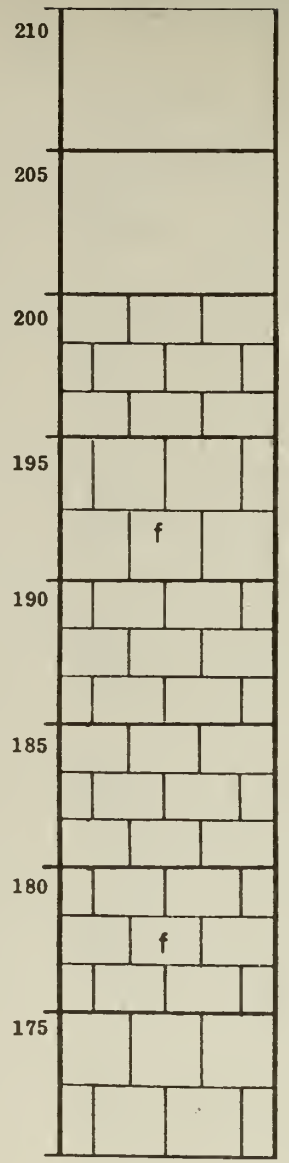
10	Mmc 35: ls., whitish buff, recryst. clastic, some vfn.-med. xln., crinoids, foss. molds, vy. sparry, some shears.
	Mmc 36: Covered - no apparent change in lith.
	Mmc 37: Covered.
	Mmc 38: Covered.
10	Mmc 39: ls., buff, similar to 35.
5	Mmc 40: ls., buff, similar to 35, some Fe stain.
5	Mmc 41: ls., buff-tan, similar to 35, vy. sparry sparite, Fe stain.
5	Mmc 42: ls., buff gry., similar to 35, brachs, recryst., clastic, sparry, sheared.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 6 of 13)



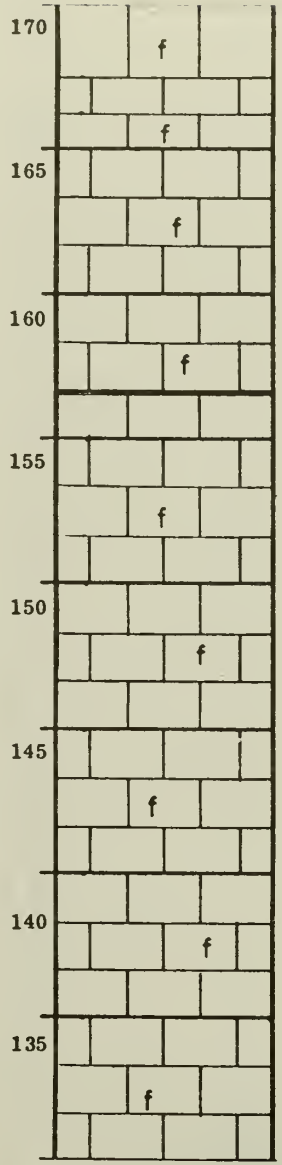
250	5		Mmc 43: ls., light gry., pelletal clastic, angular clasts, recrypt., sparry, sheared, coarse clasts.
245	10	vfn.-mic.	Mmc 44: ls., gry., vfn.-crypt. xln., dense, few sparry patches, some limonite blebs, sheared.
240	10		Mmc 45: ls., wh. gry., pelletal-clastic, sparry, recryst., few crinoids.
235	10		Mmc 46: ls., whitish gry., similar to 45.
230	5		Mmc 47: chert, silica replacing a pelletal ls., dense, heavy, about 90% silica.
225	5		Mmc 48: ls., whitish, clastic, crinoidal, sparry sheared, pelletal? brachs? recryst. occl. chert stringers--chert is a complete replacement of pelletal-clastic ls.
220	5		Mmc 49: ls., whitish, clastic, recryst., crinoids?, brachs, vy. sparry, sheared, w/ gry. chert showing dessication cracks.
215	5		Mmc 50: crinoidal ls., buff, clastic w/ milky white crinoid columnals in fn.-vfn. xln. sucrosic matrix spar. replacing foss., some chert-ls. breccia.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 7 of 13)



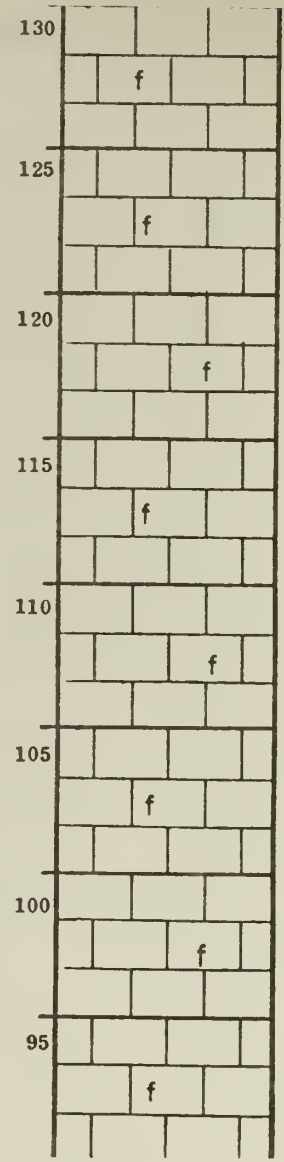
		Mmc 51: Covered.
		Mmc 52: Covered.
20		Mmc 53: ls., gry. wh., pelletal-clastic, sheared, some silica.
10	mic.	Mmc 54: ls., gry., crypt. xln., dense, lithographic, subconchoidal frac., frac., 1-3' beds, few brachs.
10	fn.	Mmc 55: ls., gry.-tan, vfn.-fn. xln., w/ some clasts recryst. pelletal, sparry.
10		Mmc 56: ls., buff-tan, pelletal-clastic, recryst., sheared, w/ chert stringers.
10		Mmc 57: ls., buff gry., pelletal, recryst. to vfn. fn. xln., crinoids, sparry, sheared.
10	M	Mmc 58: ls., buff gry., pelletal, recryst. to fn.-med. xln., sparry, sheared, beds 2-3'.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 8 of 13)



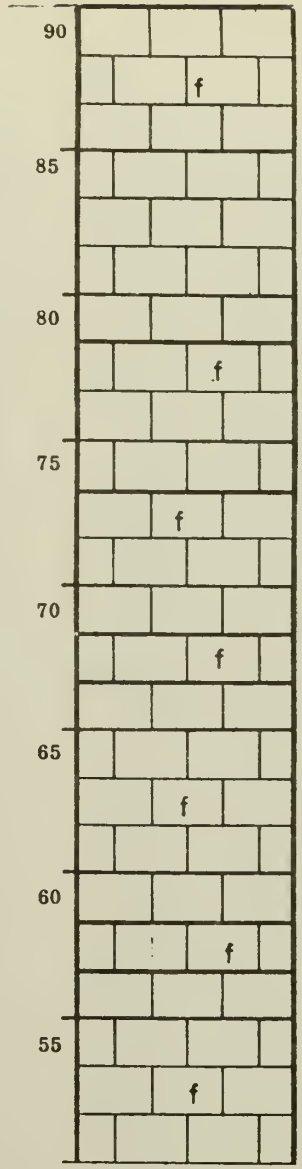
10	vfn.-mic.	Mmc 59: ls., gry., vfn.-crypt. xln., dense, brachs, formerly some pellets? sheared, beds 4-18".
10	mic.	Mmc 60: ls., gry., crypt. xln., dense, relict pelletal struct., brachs.
10		Mmc 61: ls., gry., alterate beds, vfn.-crypt. xln.; & clastic pelletal, foss. crinoidal, sparry, milky white, calcite foss. crinoids, 6" beds w/ arg. partings.
10		Mmc 62: ls., gry., pelletal, foss. hash, sparry, some hematite, recryst. mainly to med. crse. xln., brachs, corals, arg. lumps, brachs., arg. at top.
15	vfn.-mic.	Mmc 63: ls., gry.-brn., vfn.-crypt. xln., subsucrosic, still foss.
40	vfn	Mmc 64: ls., gry.-brn., vfn. xln., crinoids, brachs, Bryozoans, chert blebs, Fe stain, 2-6" beds cream colored strks., sltly arg.
15		LODGEPOLE Mlp 65: ls., gry., vfn. xln., subsucrosic patchy dolomitic, bryozoans, arg., Fe stain.
10		Mlp 66: ls., gry., vfn. xln., similar to 65, hematite blebs & fillings foss.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 9 of 13)



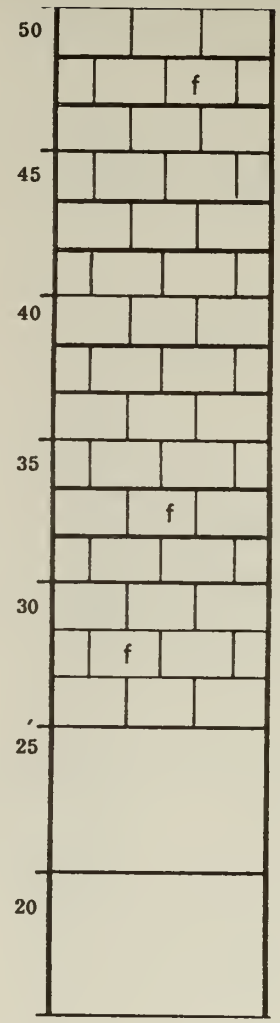
20	vfn.	Mlp 67: ls., red-gry., vfn.-mic. xln., brecciated, hematite blebs and stringers, beds 1-4" some crs. crinoidal has biosparite beds.
15	vfn.-crs.	Mlp 68: ls., purple gry., vfn.-crypt. xln., varying to crs. xln. crinoidal hash, pellets, arg. brachs, recryst, sparry, Fe stain echinoderms.
15	vfn.-crs.	Mlp 69: ls. as above, foss. mainly on weath. surface, corals, brachs, crinoids, echinoderms.
15	vfn.-crs.	Mlp 70: ls., pink-gry., ranges from vfn. xln. arg. to crs. xln. bio sparite, recryst., crinoids, brachs, echinoderms, corals, pellets, beds to 6", Fe stain.
15	vfn.-crs.	Mlp 71: ls., pink-gry-brn., similar to 70.
10	vfn.-crs.	Mlp 72: ls., gry. to gry. brn., as 70, foss. hash to vfn. arg., excellent brachs. and crinoids, much spar. replacing foss., beds 2-6".
10	vfn.	Mlp 73: ls., dk. gry., vfn., brachs, some crs. biosparite.
10	vfn.	Mlp 74: ls., buff gry., vfn. xln. w/ sparry patches, crinoid, brachs, arg., ripple marks, by thin-2" beds.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 10 of 13)



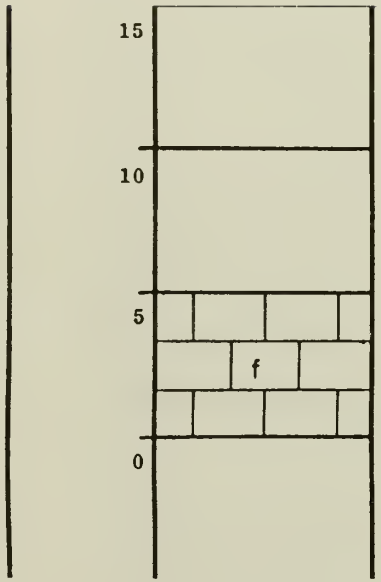
10	vfn. - crs.	Mlp 75: ls., buff gry., clastic biosparite interbedded with vfn. xln. arg. lam. ls., beds 8" to platey, brachs, shoal?, Fe stain.
10	vfn. - crs.	Mlp 76: ls., gry.-reddish, similar to 75, ripples, clay pellet & pod congl.
10	crs.	Mlp 77: ls., gry., crs. xln. biosparite, large brachs, arg. pods & strks, 6-8" beds.
10	crs.	Mlp 78: ls., buff gry., crs. biosparite, vy. foss. sltly. arg.
10	vfn. - crs.	Mlp 79: ls., light gry., vfn. xln., pelletal? sparry, occl. foss. to hash, lam. on weath. surface, arg. partings to shly beds, most thin beds but up to 12".
10	vfn. - crs.	Mlp 80: ls., gry. to buff, interbedded foss. hash-biosparite to vfn. crypt. xln. sltly. arg. dense, globalse brachs, beds as above.
10	vfn. - crs.	Mlp 81: ls., gry.-red brn., vfn.-mic. xln. arg. dense interbed w/ some crs. xln. biosparite and some brach, crinoid foss. hash w/ arg. lime mud matrix, clayey beds up to 2", ls. beds 2".
10	fn.	Mlp 82: ls., gry., similar to 82, recrystallization to fn. - vfn. xln. in part.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 11 of 13)



5		Mlp 83: ls., buff, a large brach "coquina" w/ sparry cement (biosparite), comented brach hash, arg. partings.
10	vfn.-crs.	Mlp 84: ls., buff-gry. to red, interbed med.-crs. biosparite and red vfn. xln. arg. lam. ls., platy - 6" beds.
10	vfn. crs.	Mlp 85: ls., gry. buff, as 84.
10	mic. crs.	Mlp 86: ls. gry.-buff-red, crs. xln. biosparite w/ brachs, crinoids, echinoids at top and vfn.-crypt xln., dense, foss. at base, hematite blebs and stringers, arg.
10	mic.-crs.	Mlp 87: ls., gry.-buff, same as 86, w/ white calc. filled shears & fracs.
10	mic-crs.	Mlp 88: largely covered--ls., gry.-red, similar to 86 good brachs in float.
10	crs.	Mlp 89: covered except for 6" bed at base ls., purple-gry., crs. xln. biosparite, hematite blebs, brachs, crinoids.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 12 of 13)



10	fn.-med.	Mlp 90: Covered, ls., gry., fn.-med. xln. sltly. arg., sheared in float.
10	crs.	Mlp 91: Covered, dug 2" bed, ls., gry., crs. xln. biosparite, w/ limon. spots, much weath. platey, material, coral frags. brachs, arg., sheared.
5	vfn.-crs.	Mlp 92: ls., gry., similar to 91 but med.-crs. xln. partly recryst., some foss. hash, arg., w/ vfn. xln. matrix.

BROWN'S CANYON SECTION, LITTLE ROCKIES, CENTRAL MONTANA (Sheet 13 of 13)

Surface Section - Amsden Formation

BEACON HILL

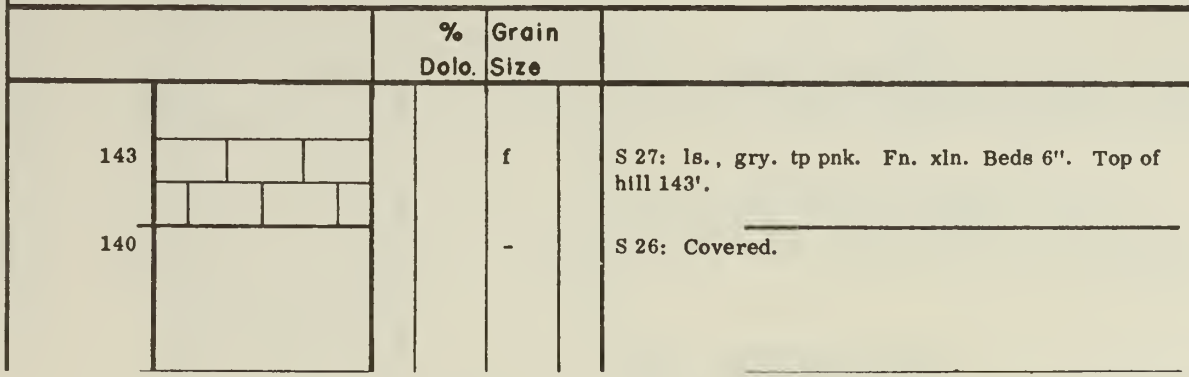
Fergus County, Montana

Section 19, T20E, R13N

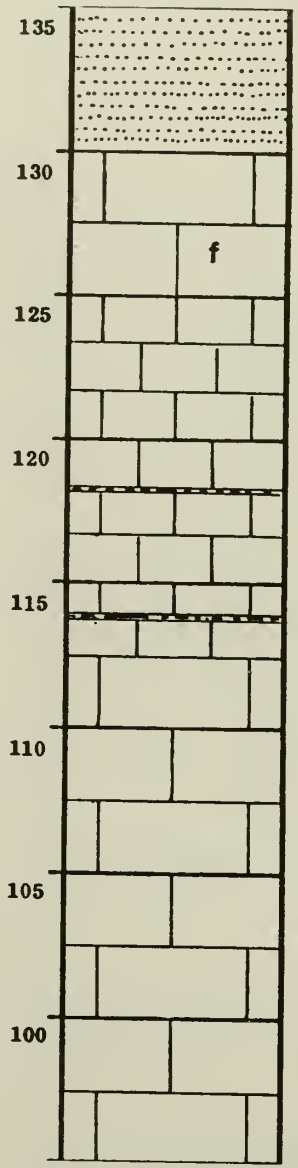
Vertical Scale: 1" = 5'

Dept. of Geol. & Geol. Eng., S.D.S.M. & T., 7/71

By: J.C.M., J.G., G.B.S.

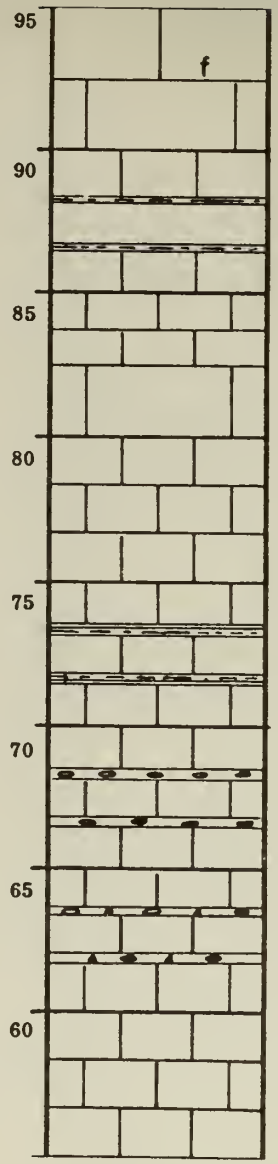


ALASKA BENCH OR BEACON HILL SECTION, BIG SNOWY MOUNTAINS, CENTRAL MONTANA (Sheet 1 of 5)



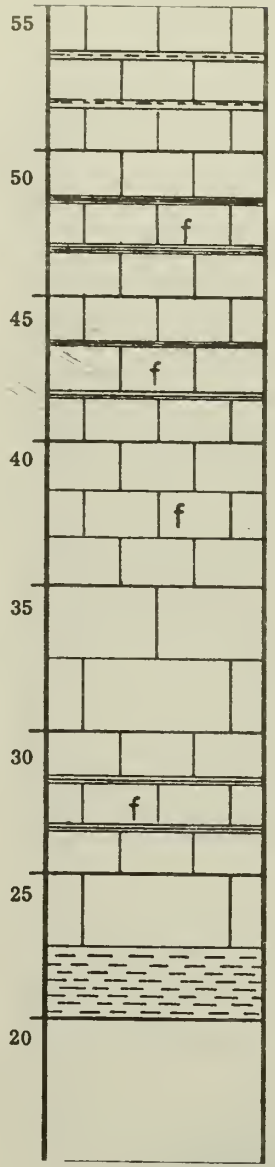
135	-	S 25: Sandstone, brn. to gry. to red. Weaths. brn. Fn. gns. Laminated thin bedded.
130	f-m	S 24: ls., gry., weaths. gry. brn. Fn. to med. xln. Calcite vugs and streaks. Brachs. Beds 2'.
125	m	S 23: ls., yel. brn. to gry. at top. Med. xln. Calcite veins. Intergran. porosity.
120	f	S 22: ls., yel. Argillaceous. Vuggy porosity. Change in lithology at 118'.
115	f	S 21: ls., pnk. yel. Fn. xln. Large calcite blebs. Slightly argillaceous. Becomes more thin bedded upward.
110	f	S 20: ls., gry. brn. Large calcite blebs. Beds 2' thick.
105	f	S 19: ls., like S 20.
100	f	S 18: ls., brn. gry. mottled pnk. Beds massive.

ALASKA BENCH OR BEACON HILL SECTION, BIG SNOWY MOUNTAINS, CENTRAL MONTANA (Sheet 2 of 5)



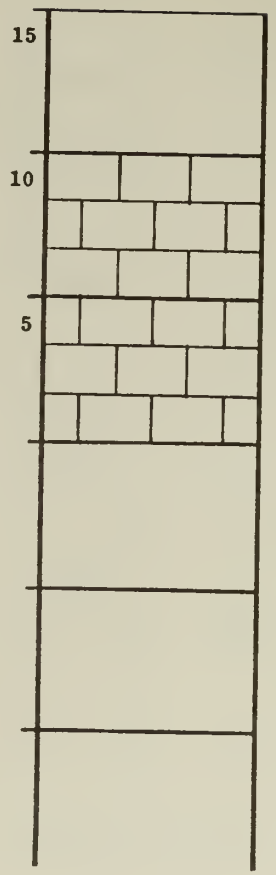
f	S 17: ls., brn. pnk. Weaths. red pnk. Fn. xln. Brachs. Beds massive.
f	S 16: partly covered. Interbedded pnk. purp. clays and thin purp. and grn. micrite. Beds 6" to platy at top.
m	S 15: ls., gry. brn. to pnk. Weaths. pnk. red. Med. xln. Beds 6" - 2'.
f	S 14: ls., gry. to pnk. Weaths. pnk. to red. Fn. xln. tough. Med. xln. calcite blebs and streaks.
f	S 13: ls., gry. pnk. weaths. red to pnk. Chert. Argillaceous, shaly streaks locally. Beds 2" - 2'.
mi	S 12: ls., gry. micrite, little sparry calc. Chert layer. Cgl. or breccia layer. Thin bedded at top.
f-c	S 11: ls., gry. to pnk. Weaths. pnk. Lower 2' massive. Upper 3' thin bedded pnk. Chert and chert-ls. breccia.
f	S 10: ls., purp. pnk. Green streaks.

ALASKA BENCH OR BEACON HILL SECTION, BIG SNOWY MOUNTAINS, CENTRAL MONTANA (Sheet 3 of 5)



55	f	S 9: ls., gry. brn. weaths. pnk. Fn. xln. Argillaceous. Beds 2".
50	f	S 8: ls., gry. Fossiliferous. Clay pellets. Qtz. grns. Interbedded thin red to purp. shale.
45	f	S 7: ls., like S 8.
40	f	S 6: ls., gry. pnk. mottled. Qtz. grns. Calcite blebs and streaks. Sparry fossil fragments.
35	mi	S 5: ls., gry. weaths. gry. brn. Micrite. Lime balls, vugs. Beds 2' variable.
30	mi	S 4: ls., gry. brn. Micrite. Oölites and fossils. 2" pnk. to purp. shale bed.
25	mi	S 3: ls., gry. brn. to pnk. Laminated micrite. Oölitic. Bed 2 1/2'. Pnk. to purp. claystone 2 1/2'.
20		Covered. Rubble is red, purple, gry. and green shale.

ALASKA BENCH OR BEACON HILL SECTION, BIG SNOWY MOUNTAINS, CENTRAL MONTANA (Sheet 4 of 5)



	-	Covered.
	f	S 2: ls., pnk. mottled red. Hematitic. Clay pellets. Some beds discontinuous red, slightly cross-bedded.
	mi	S 1: ls., gry. brn. Weaths. pnk to red brn. Micrite. Weathers rubbly. Beds 6-12".

ALASKA BENCH OR BEACON HILL SECTION, BIG SNOWY MOUNTAINS, CENTRAL MONTANA (Sheet 5 of 5)

Surface Section - Bighorn Dolomite

DAYTON SECTION

Sheridan County, Wyoming

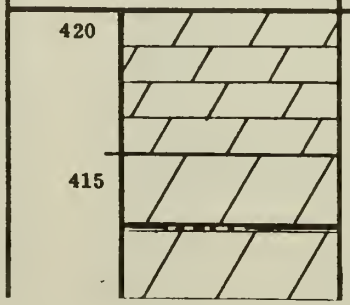
Section 21, 22, 28, T56N, R87W

US-14, East Flank of Big Horn Mts

Vertical Scale: 1" = 5'

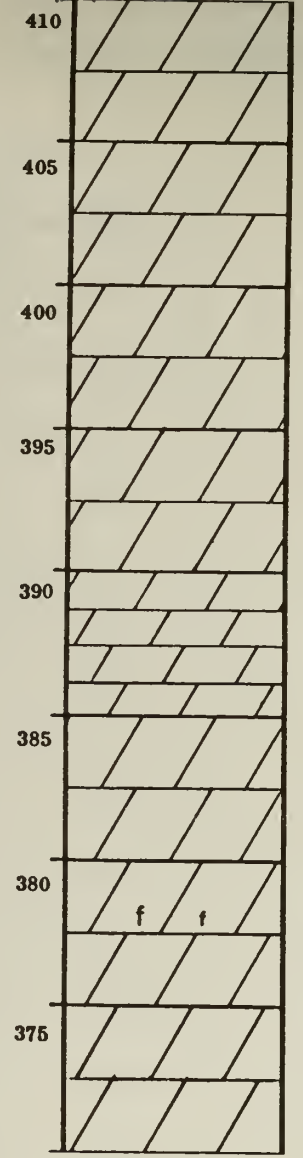
Dept. of Geol. & Geol. Eng., S.D.S.M.&T

By: J.P.G., J.G., G.B.S.



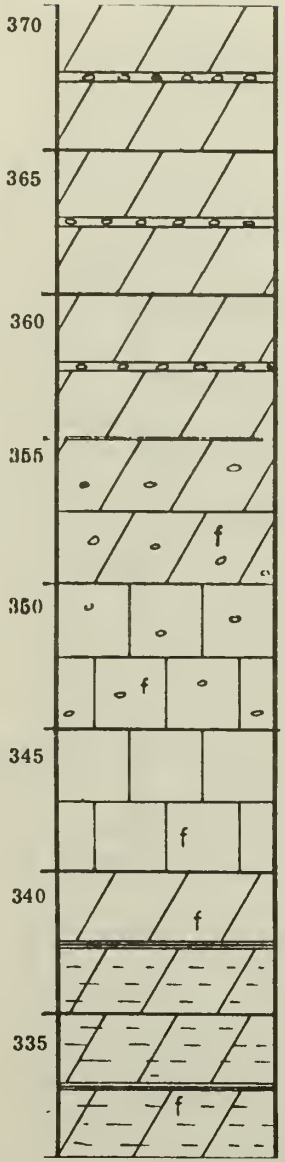
	% Dolo.	Grain Size	
420	90	vfn.-mic.	Day Ob 84: dolo., buff, vfn. crypt. xln., sub. litho., conchoidal frac., blocky, lam.
415	85	vfn.-mic.	Day Ob 83: dolo., buff yell. tan mottled, vfn.-crypt. xln. limon. stain, arg., some fissility in clayey zones.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 1 of 12)



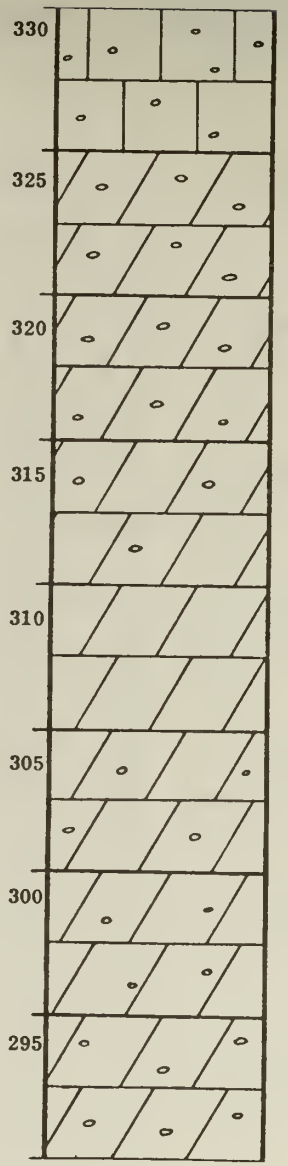
85	mic.	Day Ob 82: dolo., buff, crypt. xln., conchoidal frac., massive-blocky, 6" to 18", dense, some mottling.
85	vfn.-mic.	Day Ob 81: dolo., gry. buff, vfn.-crypt. xln., sheared, mottled irreg. beds, dense.
90	mic.	Day Ob 80: dolo., cream buff, yell., crypt. xln., sub-conch. frac., massive to irreg. beds.
85	vfn.-mic.	Day Ob 79: dolo., gry. buff, vfn.-crypt. xln., brecciated by soln., massive.
90	vfn.	Day Ob 78: dolo., gry., vfn. xln., arg., flaggy, rounded, knobby.
85	vfn.-mic.	Day Ob 77: dolo., yell.-brn., vfn.-crypt. xln., arg., some inter xln. por., conchoidal frac., massive.
85	vfn.	Day Ob 76: dolo., gry. tan w/ yell. mottling, vfn. xln., slight vuggy por., foss. relicts, occl. strks. and blebs of calc.
90	vfn.	Day Ob 75: dolo., buff mottled w/ brown, vfn. xln. sucrosic, calcite blebs cream white to clear sparry, pin point poros, some vugs, massive to slabby beds.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 2 of 12)



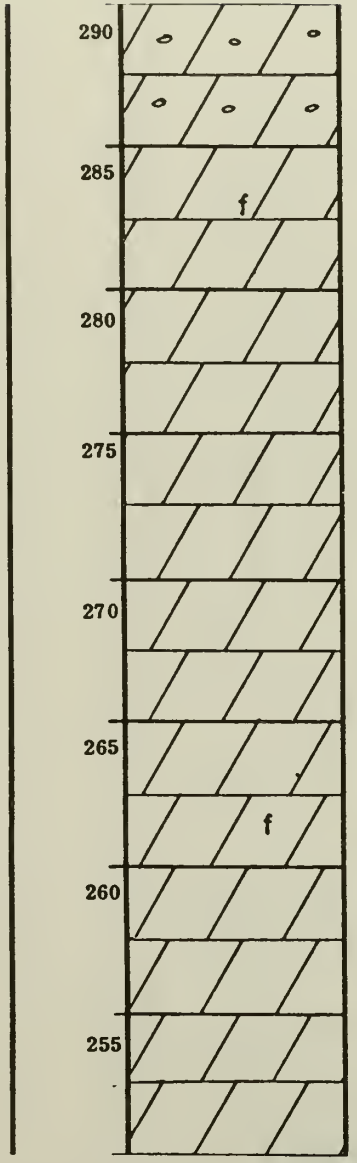
80	fn.	Day Ob 74: dolo., buff tan with dk. brn. mottling, fn. xln., recryst., good inter. xln. por., some vugs, chert layers and nods.
90	vfn.	Day Ob 73: dolo., buff tan, vfn. xln., somewhat siliceous, some calc. in vugs, qtz, pink & gry. mottling, chert layers, gry. & brn.
90	fn.	Day Ob 72: dolo., gry., fn. xln. sucrosic, chert nodules gray, some calc., dk. brn. mottling, chert layers, some pin point, vuggy, inter xln. por.
80	vfn.	Day Ob 71: dolo., buff tan, vfn. xln., sucrosic, calc., dk. brn. mottling, gastropod, some shearing, brown chert nods and beds, mass. to slabby irreg. beds.
30	vfn.	Day Ob 70: ls., buff yell., vfn. xln., sucrosic in part, calc. could be largely inter xln. and in foss. relics, sheared, brn. chert nods, occl. sparry calc., some mang.
35	vfn.	Day Ob 69: ls., buff tan, similar to 70, more foss. molds, relics, crinoids.
65	vfn.	Day Ob 68: dolo., mottled yell.-buff-gry., vfn. xln., many sparry calc. foss. molds & relicts, limon. stain, shly partings, massive beds.
65	vfn.-mic.	Day Ob 67: clayey dolo., mottled gry. grn. pink buff, vfn.-crypt. xln., arg., blebs sparry calc., lam? foss? massive w/ shly partings.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 3 of 12)



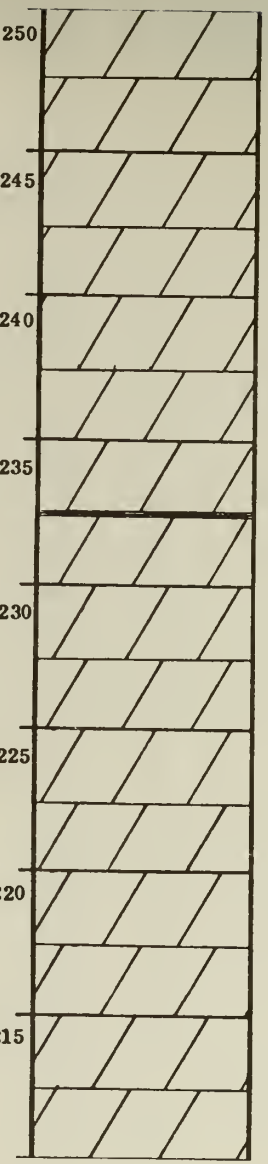
20	vfn.-crs.	Day Ob 66: ls., mottled gry. buff, vfn. xln. to crs., sparry, some banding, recryst., massive to irreg. beds, occl. brn. chert nods.
80	vfn.	Day Ob 65: dolo., buff yell., mainly vfn. xln., sucrosic, w/ crs. xln. qtz. along fracs, chert nods, brn., good inter xln. & vuggy por., limon. stain vugs.
85	vfn.-mic.	Day Ob 64: dolo., mottled buff yell.-gry. tan, vfn.-crypt. xln., occl. small vugs, some inter xln. calc., some chert, massive.
90	vfn.-mic.	Day Ob 63: dolo., buff tan, vfn.-crypt. xln., dense, sheared, chert nods, brn. inside w/ yell.-white outer weath. rind, massive beds.
90	vfn.-mic.	Day Ob 62: dolo., buff yell. tan, similar to 63, w/ mang. dend.
90	vfn.-mic.	Day Ob 61: dolo., buff tan, vfn.-crypt. xln., dense, sheared, chert nods, sucrosic in some areas w/ good inter xln. por.
85	vfn.	Day Ob 60: dolo., buff gry. mottled, mainly vfn. xln., occl. crs. xtal. or blebs, some shears, occl. calc., massive bed, gry. chert. @ 297' BM 63+50 U. S. B. P. R.
85	vfn.	Day Ob 59: dolo., mottled buff gry., mainly vfn. xln. w/ occl. med.-crs. xln., vuggy por., some inter. xln. & vuggy por., limon. stain in vugs, massive beds, gry. chert nods common.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 4 of 12)



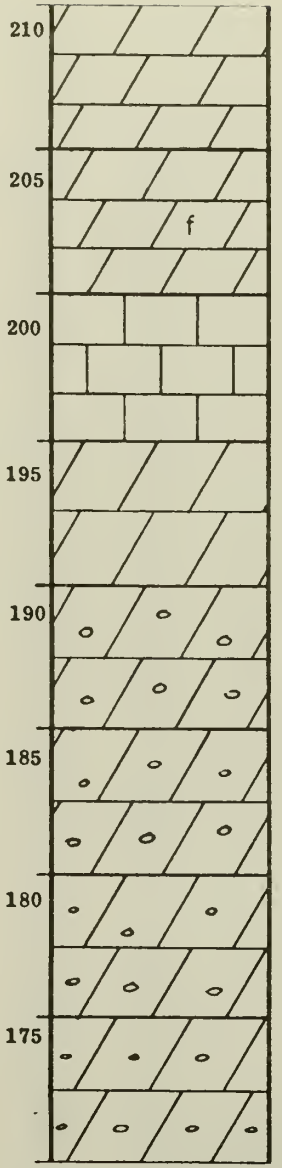
90	vfn.	Day Ob 58: dolo., mottled gry. tan, vfn.-xln., some vugs, gry. chert rods and bands, massive - irreg. beds.
90	vfn.	Day Ob 57: dolo., mottled gry., vfn. xln., occl. vugs and molds, shears, massive, occl. spar.
90	vfn.-mic.	Day Ob 56: dolo., lt. gry., vfn.-crypt. xln., shears, blocky, dense, some mang. dend.
90	vfn.-mic.	Day Ob 55: dolo., buff gry., vfn.-crypt. xln., dense, some banding, mang. dots, pelletal?, dense, massive beds, blocky, veins.
85	vfn.-mic.	Day Ob 54: dolo., buff tan, vfn.-crypt. xln., some calc. in blebs, vugs, inter xln., mang. stain, massive.
80	vfn.-mic.	Day Ob 53: dolo., whitish gry., vfn.-crypt. xln., brecciated, calc., foss. relicts, some sparry calc., recryst., massive to irreg. beds.
80	fn.-vfn.	Day Ob 52: dolo., banded tan to gry., vfn.-fn. xln., vuggy, soution evidence, recryst., mang. dend.
85	vfn.-med.	Day Ob 51: dolo., gry., vfn.-med. xln., recryst., solution features, Mn. dend., spongey in part, weathered, mang. dend.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 5 of 12)



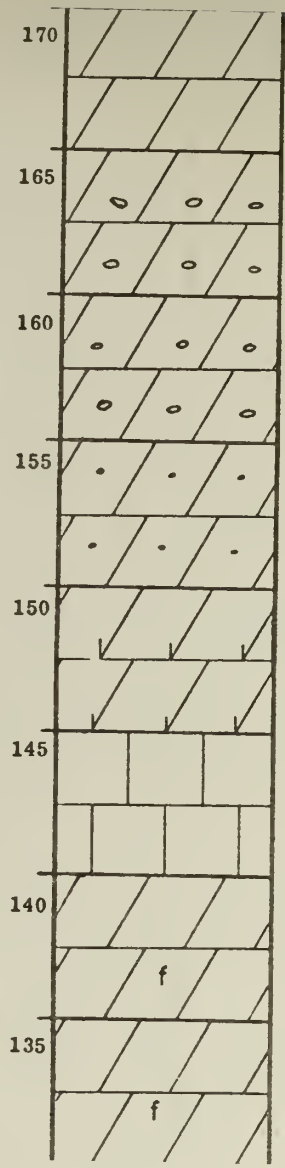
250	85	vfn.-med.	Day Ob 50: dolo., light gry., vfn.-med. xln., recryst., some sparry calc., Mang, dend., solution breccia, vuggy, massive.
245	85	vfn.-crs.	Day Ob 49: dolo., light gry., vfn.-crs. xln., recryst., brecciated-solution, spongey, vuggy, massive.
240	85	vfn.	Day Ob 48: dolo., buff tan, vfn. xln., sucrosic, inter xln. por., massive, sli. arg.
235	85	vfn.-mic.	Day Ob 47: dolo., light gry., crypt. xln. dense, vfn. xln. sucrosic recryst., crs. xln. spar., brecciated, Mn stain, some arg.
230	90	vfn.-mic	Day Ob 46: dolo., light gry., vfn.-crypt. xln., subsucrosic, pin point pores, some inter xln. calc. and porosity, blocky.
225	90	vfn.-mic.	Day Ob 45: dolo., light gry., similar to 46, some shears, no pin point pores.
220	90	vfn.-mic.	Day Ob 44: dolo., similar to 45, some Mn. dots.
215	90	vfn.-mic.	Day Ob 43: dolo., similar to 44.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 6 of 12)



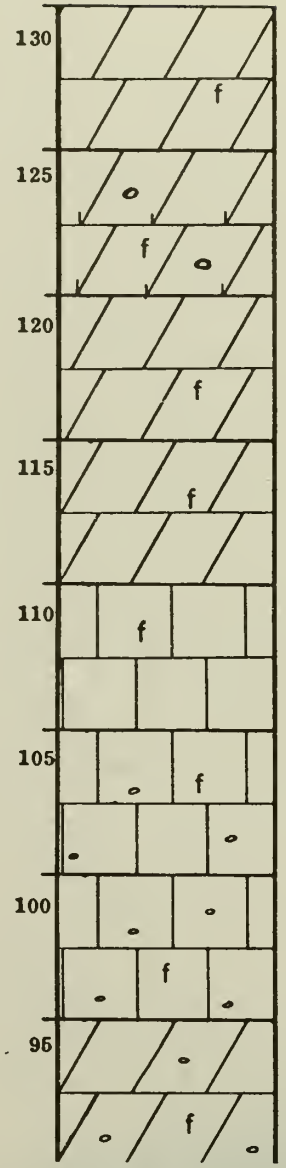
90	vfn.-mic.	Day Ob 42: dolo., similar to 44, apparent lam., some pink lam., uneven platey to slabby beds.
60	vfn.-fn.	Day Ob. 41: dolo., light gry., vfn.-fn. xln., w/ med. crs. xln. sparry calc., prob. foss. relicts, sparry calc. patches as inter xln. cement, uneven slabby bedding.
20	fn.-vfn.	Day Ob 40: ls., gry. tan, fn.-vfn. xln., w/ sparry calc. in streaks, blebs, & fracs, sheared, slabby bedding.
60	vfn.	Day Ob 39: limey dolo., buff tan, mainly vfn. xln. w/ inter. xln. calc. and calc. in fracs., veins and sparry blebs.
80	fn.-vfn.	Day Ob 38: dolo., light gry., mainly fn.-vfn. xln., sheared parallel to bedding, calc. in fracs., gry. brn. chert nods.
85	vfn.-mic.	Day Ob 37: dolo., buff tan, vfn.-micro. xln., sub sucrosic, sli. arg., shears, lam?, chert nods, massive to irreg. bedding.
80	vfn.-crypt.	Day Ob 36: dolo., buff, vfn.-crypt. xln. dense, siliceous, chert, sheared, lam?
85	vfn.	Day Ob 35: dolo., buff tan, vfn. xln., subsucrosic Mn spees, chert, lam?, massive to irreg. beds.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 7 of 12)



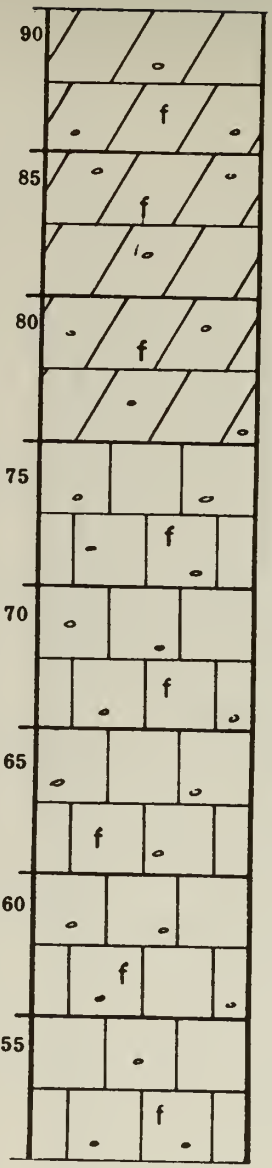
85	vfn.-mic.	Day Ob 34: dolo., buff tan gry., vfn.-crypt. xln., dense, Mn specs., lam?, some arg., siliceous in places, inter xln. por., sheared, massive to irreg.-indef. bedding.
85	vfn.-mic.	Day Ob 33: dolo., buff gry., vfn.-micro. xln., dense, some arg., some siliceous blebs, silicified areas, some black chert, massive to irreg. beds, weaths. buff yell. BM 5870 U. S. B. P. R. @ 163.
85	vfn.-med.	Day Ob 32: dolo., gry., vfn.-med. xln., dense, siliceous, Mn inclus. black chert, massive to irreg. beds, spring along fracs?
80	vfn.-med.	Day Ob 31: dolo., buff tan - lt. gry. mottled, vfn.-med. xln. chert blebs, somewhat soln. brecciated, weathered in part w/ inter xln. por., some calc. in veins & vugs, massive to irreg. beds.
60	vfn.-med.	Day Ob 30: limey dolo., mottled yell.-buff to light brn., vfn.-med. xln., the yell. buff areas are less well cemented and more dolo., sheared, some Mn dend., occl. chert, massive to irreg. beds.
20	vfn.	Day Ob 29: ls., mottled yell. buff-gry. buff, mainly vfn. xln. subsucrosic, w/ occl. crs. calc. xtals., sheared, vuggy, some limon strain, chert, massive to irreg. beds. Near culvert BM 6927 707 U. S. B. P. R.
65	vfn.-crs.	Day Ob 28: limey dolo., mottled buff gry.-tan, vfn. xln. w/ sparry calc. inclusions, recryst. foss. relicts, crinoids, brachs, Mn specs, beds 10" to 2', gry.-brn. blk. chert.
45	vfn.-crs.	Day Ob 27: dolo., mottled buff gry.-tan, vfn.-crs. xln., sparry calc. foss. relicts recryst., sli. arg., crinoids, sheared, Mn specs, chert, massive to irreg. beds.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 8 of 12)



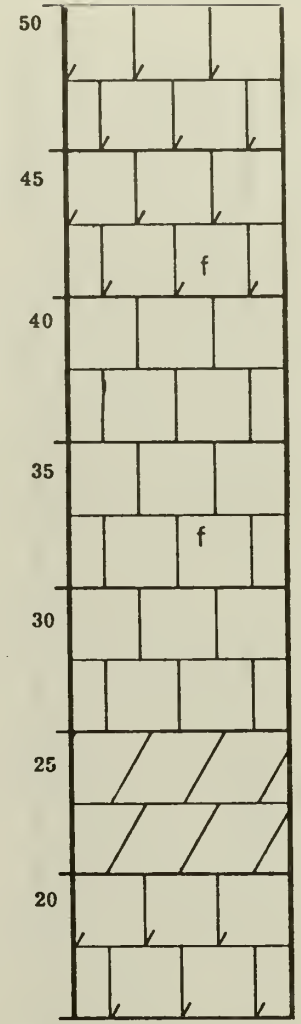
45	vfn.-crs.	Day Ob 26: dolo. ls., similar to above, weaths. mottled yell.-buff.
60	vfn.-crs.	Day Ob 25: limey dolo., mottled buff. gry.-buff tan, vfn.-xln. with med.-crs. xln. sparry inclusions, foss. relicts?, shears, sli. arg., occl. vugs, chert.
35	vfn.-crs.	Day Ob 24; dolo. ls., mottled light gry.-buff tan, vfn.-crs. xln. biosparite, recrypt. brachs, crinoids, corals, occl. chert, massive to irreg. beds, sli. arg.
35	vfn.-crs.	Day Ob 23: dolo. ls., similar to 24.
20	vfn.-mic.	Day Ob 22: ls., gry. tan, vfn.-crypt. xln., recryst. biosparite clastic, sparry recryst. foss., brachs, crinoids, echinoid?, corals, sli. arg., sheared, massive beds, chert nodules to 3", appears dense.
25	fn.-vfn.	Day Ob 21: ls., mottled gry.-tan, fn.-vfn. xln., recryst. pelletal biosparite, foss. as in 22, rather dense, Mn specs., chert.
30	vfn.-med.	Day Ob 20: ls., mottled light gry.-buff tan, vfn.-med. xln., biosparite recrypt., foss. relics, cherty, massive to irreg. beds.
40	crs.-mic.	Day Ob 19: dolo. ls., mottled tan gry.-yell. tan, mainly vfn.-mic. xln., w/ med.-crs. xln. spar., foss. relicts, recryst. biosparite?, limon stain on fracs, chert, massive.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 9 of 12)



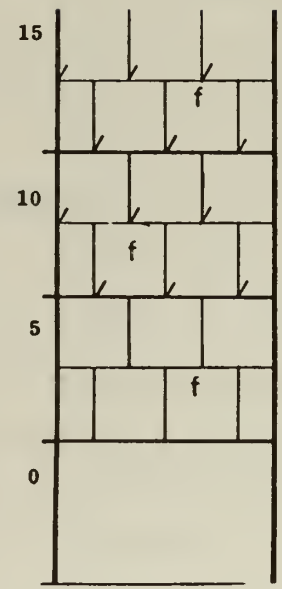
40	crs.-mic.	Day Ob 18: dolo. ls., med. gry., similar to 19.
45	crs.-mic.	Day Ob 17: dolo. ls., med. gry., similar to 19.
40	crs.-mic.	Day Ob 16: dolo. ls., mottled pink-gry. tan-buff, similar to 19.
25	crs.-mic.	Day Ob 15: ls., tan gry., vfn.-micro. xln. w/ med.-crs. xln. spar., recrypt, biosparite, brach. molds, arg., some shears, chert, massive to irreg. beds.
25	crs.-mic.	Day Ob 14: ls., buff gry., similar to 15.
25	crs.-mic.	Day Ob 13: ls., tan gry., similar to 15 more med.-crs. xln. biosparite, corals, crinoids, brachs.
25	crs.-mic.	Day Ob 12: ls., buff tan, similar to 13, some limon. stain, crinoids.
25	crs.-mic.	Day Ob 11: ls. buff, similar to 12.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 10 of 12)



40	crs.-mic.	Day Ob 10: dolo. ls., buff mottled, vfn.-micro. xln. w/ med.-crs. xln. sparite, recryst. biosparite, occl. chert.
40	crs.-mic.	Day Ob 9: dolo. ls., mottled gry.-buff, vfn.-micro. xln. w/ med.-crs. xln. biosparite, calc. on fracs. and in veins and blebs, crinoids, ostracods.
25	crs.-mic.	Day Ob 8: ls., mottled yell. brn.-gry., vfn.-mic. xln. w/ med.-crs. xln. biosparite, chert, sli. arg., chert, massive.
25	crs.-mic.	Day Ob 7: ls., some gry. brn. some mottled pink-gry., vfn.-mic xln. w/ biosparite, receptaculites, chert.
40	crs.-mic.	Day Ob 6: ls., mottled brn.-buff, vfn.-micro. xln. w/ med.-crs. xln. biosparite, chert.
30	fn.-med.	Day Ob 5: dolo., mottled pink, yell. brn., fn. xln., w/ some sparry calc. clasts, sli. arg., chert, stylolites, looks brecciated.
40	crs.-mic.	Day Ob 4: dolo. ls., dolo mottled pink to brn.gry.-dolo. is gry., vfn.-micro. xln., w/ med.-crs. xln. spar., chert nods, stylolites, cherty vugs.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 11 of 12)



40	mic.-crs.	Day Ob 3: dolo. ls., mottled to banded pink-gry.-brn., vfn.-micro. xln. w/ some med.-crs. xln. spar. silica replacement - chert, some limon. stain, massive to irreg. beds, stylolites, occl. vug, relic sparry foss., crinoid.
40	mic.-crs.	Day Ob 2: dolo. ls., similar to 3, less chert.
20	vfn.-mic.	Day Ob 1: ls., mottled buff-yell. brn., mainly vfn.-micro. xln., sucrosic, w/ some med. xln. spar., foss. relics?, sli. arg., good inter xln. por., massive - irreg. beds, weaths. buff yell., some limon. stain on fracs.
		COVERED.

DAYTON - BIG HORN SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 12 of 12)

Surface Section- Madison Limestone

DAYTON SECTION

Sheridan County, Wyoming

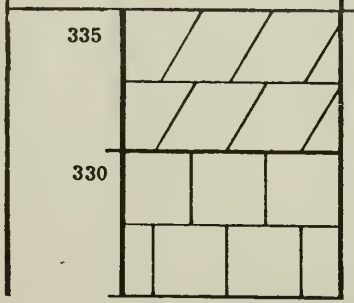
Section 21,22,28, T56N, R87W

US-14, East Flank of Big Horn Mts.

Vertical Scale: ,1" = 5'

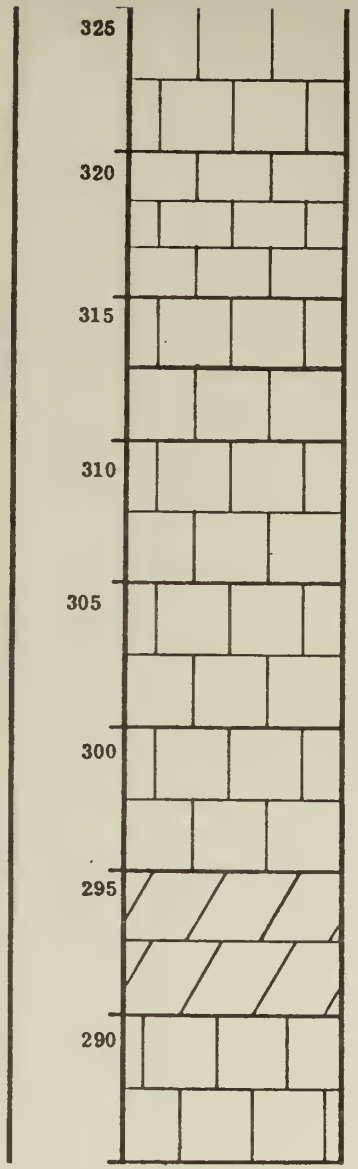
Dept. of Geol. & Geol. Eng., S.D.S.M. & T. 7/71

By: J.P.G., J.G., G.B.S.



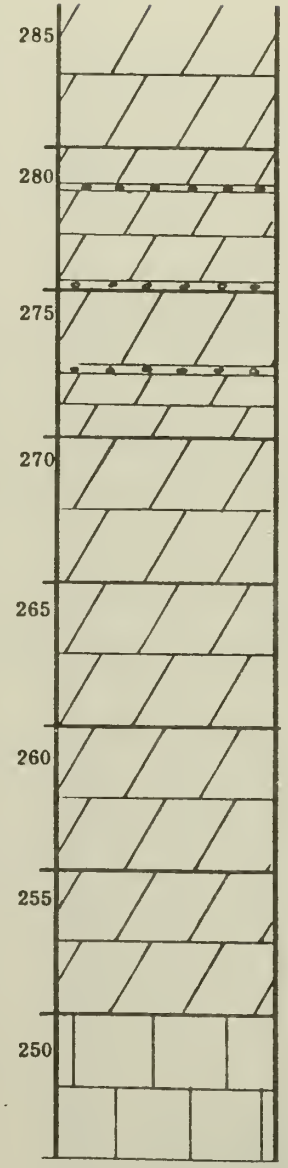
	% Dolo.	Grain Size	
335	60	vfn	Day Mm 67: limey dolo., white, vfn. xln., sucrosic, w/ inter xln. calc. cement and inclusions, massive pink and yell. surface stain.
330	25	vfn-mi	Day Mm 66: ls-pelletal, gry-tan, vfn-crypto xln., foss? Pellets 1/2 - 1 mm sheared, massive, 2-4" purple beds.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 1 of 10)



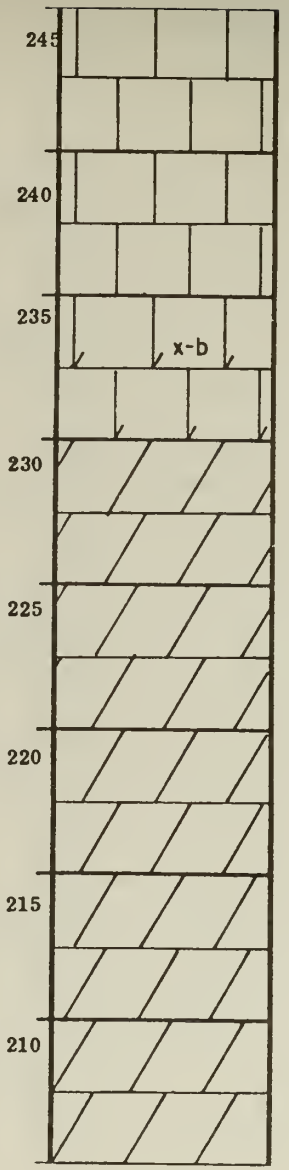
325	20	fn-med	Day Mm 65: ls., gry-purple, fn.-mcd. xln., sparry, purple lumps, sheared, lams., x-beds, 6"-2' beds, red & yellow surface stain.
320	20	vfn-med	Day Mm 64: ls., gry., vfn.-med. xln., some clasts or pellets? Fracs. recemen. w/ calc., Mn. & limon. stain.
315	25	crs	Day Mm 63: ls., tan, clastic 1-2 mm. clasts w/ sparry cement, clasts are vfn.-crypto xln., white cal. blebs.
310	25	crs	Day Mm 62: ls., lt. gry., clastic-pelletal-1 mm., w/ sparry cement, clasts vfn.-crypt. xln. sheared, massive.
305	20	crs	Day Mm 61: ls., tan, clastic, clasts fn.-vfn. xln., ± 1 mm., massive.
300	5	crs	Day Mm 60: ls., tan, clastic, clasts vfn.-crypt. xln., ± 1 mm., sparry cement, pellets? Massive.
295	65	fn-vfn.	Day Mm 59: limey dolo., gry.-brn., fn.-vfn. xln., w/ inter xln. cal. cement, beds 1-3'.
290	15	vfn-mi.	Day Mm 58: ls., gry.-brn., vfn.-crypt. xln., dense, sheared, conch. frac., massive.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 2 of 10)



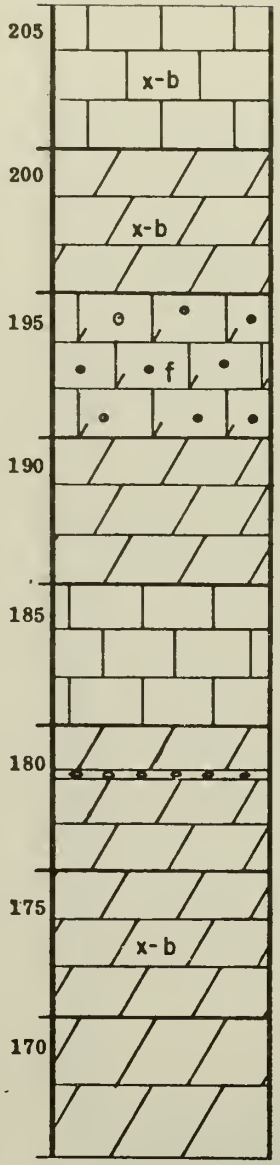
285	75	fn-vfn.	Day Mm 57: dolo., gry.-tan, fn.-vfn. xln., w/ interxln. calc. cement, sheared, hackly frac., recem. pelletal? Massive.
280	70	vfn.	Day Mm 56: dolo., gry.-brn., vfn. xln., sucrosic, w/ inter xln. calc., occl. chert bands, top of ledge some shears, occl. 1-2" calc. lined vugs.
275	65	vfn.-fn.	Day Mm 55: limey dolo., gry.-brn., vfn.-fn. xln., w/ occl. white calc. inclusions & blebs, inter xln. calc. cement, occl. chert bands purple-gry., faint lams., some vuggy porosity.
270	75	vfn.-med.	Day Mm 54: dolo., gry. brn., vfn.-med. xln., some shears some Fe stain, 1-3' beds.
265	80	vfn.	Day Mm 53: dolo., gry.-tan, vfn. xln., similar to 52 sheared, massive, purple-red Fe stained xtals.
260	85	vfn.	Day Mm 52: dolo., gry.-brn., vfn. xln., w/ vfn. lam. and some brn.-red hematite lam. occly. contorted, calc. & hem. recem. fracs., some arg.
255	70	fn.-vfn.	Day Mm 51: dolo., gry.-brn., fn.-vfn. xln., some vuggy por., some inter xln. calc., limon. stain & in vugs.
250	20	crs.	Day Mm 50: ls., gry.-brn., crs. xln., crs. calsts, w/ inter xln. calc. cement., frac.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 3 of 10)



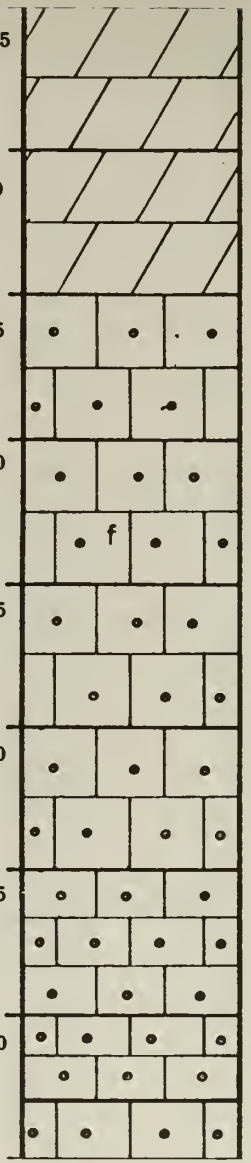
20	crs.	Day Mm 49: ls., purple-gry., crs. clastic, some Fe stain, some arg., few vugs, foss., fn. xln. Fe stained xtals., massive.
30	fn.	Day Mm 48: ls., purple gry., mainly fn. xln., similar to 47, recryst., textural banding.
50	fn.-crs.	Day Mm 47: ls.-dolo., purple gry., fn.-crs. xln., x-bedded, stylolites, foss., some arg., some Fe stain, some 2-6" calc. lined vugs massive.
60	fn.	Day Mm 46: limey dolo., banded red brn. & tan, fn. xln., bioturb? Arg., calc. inter xln. and in fracs., Fe stain, some 2-6" calc. lined vugs, massive.
80	fn.	Day Mm 45: dolo., gry., fn. xln., sucrosic, inter xln. calc. some arg.
70	fn.-vfn.	Day Mm 44: dolo., mottled purple and gry., fn.-vfn. xln., inter xln. calc., some arg., Fe stain.
80	vfn.	Day Mm 43: dolo., purple and gry. banded, vfn. xln., banding color rather than texture, purple Fe-Mn mineral, fracs, Fe stain, some arg., lam? Massive.
85	vfn.	Day Mm 42: dolo., gry.-yel.-pink, vfn. xln., sucrosic, calc. in fracs., limon. stain, lam., arg. strks., massive, rough pitted weath. surface.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 4 of 10)



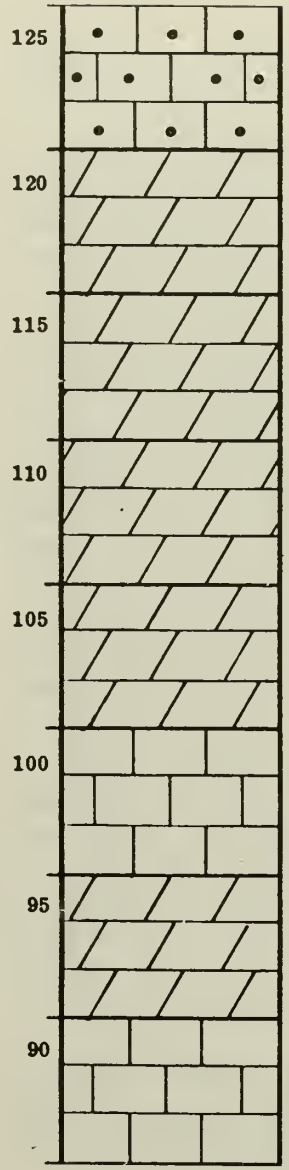
15	-	Day Mm 41: ls., gry.-brn., oolitic-pelletal, 1/2 mm. oolites, purple Fe-Mn xtals., recryst., limon. stain, milky white calc. laths., lams and x-beds.
75	vfn.	Day Mm 40: dolo., tan, vfn. xln. but some pellets in bands, calc. inter xln. and in fracs., some arg., sheared, lams. and x-beds, weaths. rough & pitted on pellets.
50	-	Day Mm 39: ls.-dolo., tan, breccia, oolitic, foss., w/ purple Fe or Mn xtals., sheared beds 1-3'.
85	vfn.	Day Mm 38: dolo., gry., vfn. xln., sucrosic, w/ inter xln. calc., mottling, sheared.
25	micro	Day Mm 37: ls., tan, crypt. xln., dense, shears, Fe stain, Mn stain, massive.
70	fn.-vfn.	Day Mm 36: dolo., whitish tan, fn.-vfn. xln., sucrosic, arg? 4" red chert band @ 177'.
70	fn.-vfn.	Day Mm 35: dolo., tan, fn.-vfn. xln., sucrosic, w/ inter xln. and frac. fill calc., some brecciation, lumps? pp por., banded vfn.-fn. xln. and x-bedded.
70	vfn.	Day Mm 34: dolo., white, vfn. xln., sucrosic, w/ inter xln. calc., few crs calc. xtals., beds 18"-massive lam.?

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 5 of 10)



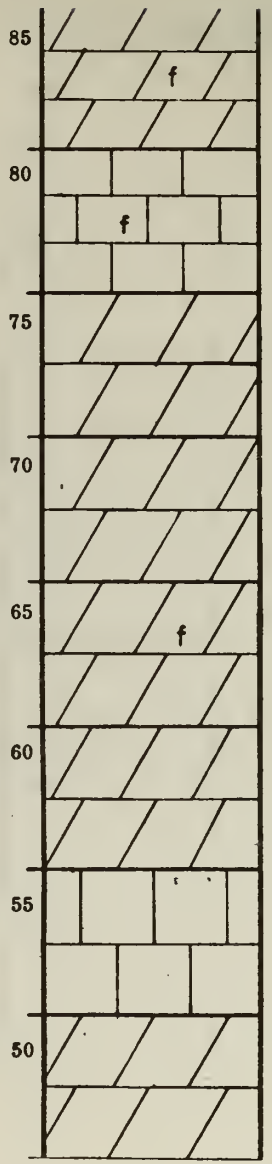
165	70	vfn.	Day Mm 33: dolo., tan, vfn. xln., sucrosic, fracs. recemen. w/ calc., Mn stain.
160	85	micro	Day Mm 32: dolo., tan, crypt. xln., sheared & recemen. w/ sparry calc., Fe and Mn stain, massive, lam.?
155	10	-	Day Mm 31: ls., tan, oolitic ± 1/4 mm., pellets, sheared, massive, ledge former.
150	10	med.-crs.	Day Mm 30: ls., gry. tan, med.-vy crs. xln., recryst? Clastic? Foss?
145	10	-	Day Mm 29: ls., tan, oolitic, largely recryst. almost crypt xln., sheared and recemen. w/ calc.
140	10	-	Day Mm 28: ls., gry.-white, oolitic ± 1/4 mm., well cemen. w/ calc., some shear & recemen.
135	10	-	Day Mm 27: ls., lt. tan, oolitic, well cemen., some recryst. and sparry, inter oolite cement, Mn stain massive, hackly frac., ledge former.
130	10	-	Day Mm 26: ls., lt. tan, oolitic, well cemen., some recryst. to vfn. xln., Mn stain.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 6 of 10)



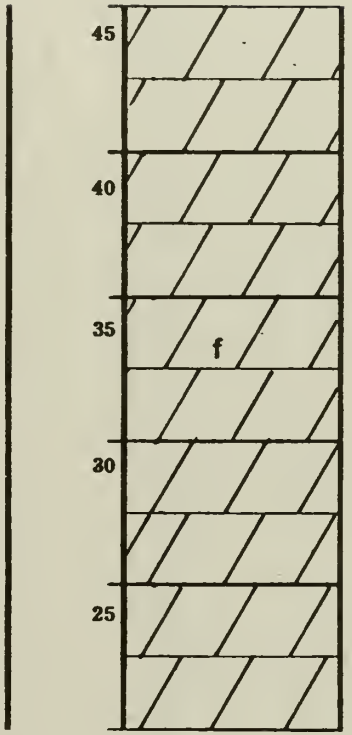
10	-	Day Mm 25: Ls., white, oolitic 1/2-1/4 mm., well cemen., massive, blocky frac.
60	crse	Day Mm 24: limey dolo., tan, w/ secondary lumps or aggregates, mottled, calc. blebs.
65	-	Day Mm 23: dolo., tan, pelletal? Dolo. mottling, calc. veins.
80	fn-vfn.	Day Mn 22: dolo., lt. tan, fn.-vfn. xln., sucrosic, some inter xln. por., lam?
80	fn.-vfn.	Day Mm 21: dolo., lt. tan, fn.-vfn. xln., sucrosic, inter xln. and vuggy calc., vuggy por., cavernous in part.
5	fn.-mic.	Day Mm 20: ls., lt. gry., fn.-micro. xln., sub litho., sheared.
85	vfn.	Day Mm 19: deolo., gry.-tan, vfn. xln., sucrosic, inter xln. calc., shears.
30	vfn.	Day Mm 18: ls., lt. gry., vfn. xln., some pink & tan mottling, lam.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 7 of 10)



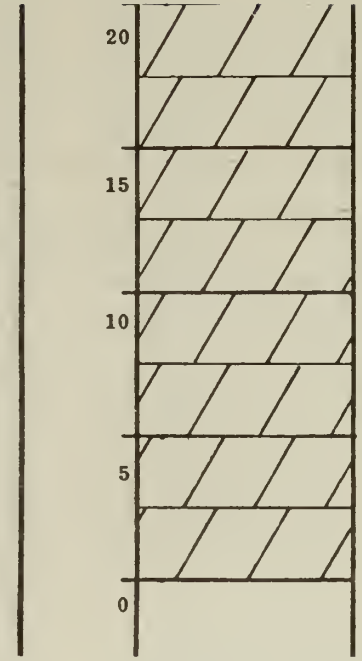
80	fn.-vfn.	Day Mm 17: dolo., gry., fn.-vfn. xln., inter xln. and vein calc., sucrosic, sheared, foss. corals syring. & zoph.
30	vfn.-crs.	Day Mm 16: ls., gry.-buff, vfn.-crs. xln., clastic? Foss. corals, calcite blebs, spar, sheaved and frac., pink stain, lam.?
70	fn.-crs.	Day Mm 15: dolo., gry.-tan, fn.-crs. xln., inter xln. calc., pink inclus. & stns., sheared & recem.
90	fn.-vfn.	Day Mn 14: dolo., lt. gry., fn.-vfn. xln., sucrosic, some small vugs and inter xln. por., tr. Fe stain.
85	vfn.	Day Mm 13: dolo., gry.-tan, vfn. xln., sucrosic, w/ inter xln. calc., occl. calc. inclus., foss. molds?
80	vfn.	Day Mm 12: dolo., lt. tan, vfn. xln., sucrosic, w/ inter xln. calc., some por., occl. larger calc. inclus. scattered vugs.
20	fn	Day Mm 11: ls., white gry., fn. xln., vuggy w/ calc. lining, sltly. arg., 1-4" dolo. nods @ 53'.
90	fn-vfn.	Day Mm 10: dolo., tan, fn. vfn. xln., sub sucrosic, few small vugs.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 8 of 10)



45	90	vfn.	Day Mm 9: dolo., tan, vfn. xln., sucrosic, dolo. mottling, sheared, vugs @ 43'.
40	90	vfn	Day Mm 8: dolo., tan, vfn. xln., sub sucrosic, sheared & frac., small Mn inclus. & dend.
35	85	vfn.	Day Mm 7: dolo., tan, vfn. xln., w/ calc. in vugs & fracs. vuggy por., foss. molds - crinoid pinules, 1-4" vugs.
30	70	fn.-vfn.	Day Mm 6: dolo., tan, fn. vfn. xln., mottled, small vugs w/ calc. lining, calc. veins, 1' crypt. xln. marker bed @ 25'.
25	75	micro	Day Mm 5: dolo., tan, micro. xln. small Mn inclus., vuggy por., sheared, forms shear wall, massive.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 9 of 10)



20	80	vfn.
15	85	vfn.-mic.
10	75	fn.-vfn.
5	90	fn.-mic.
0	-	-

Day Mm 4: dolo., gry.-tan, vfn. xln., sucrosic, good inter xln. por., sltly arg. massive, cliff former.

Day Mm 3: dolo., tan, vfn.-micro. xln. frac. w/ calc., vuggy, massive, weaths. pitted-vuggy, sltly. arg.,

Day Mm 2: dolo., tan, fn.-vfn. xln., pink-brn. mottling, calc. in fracs., stylolites, massive.

Day Mm 1: dolo., lt. gry., fn.-micro. xln., black small carbonaceous inclus. & strks., calc. vugs, massive, purple bands from 5-2.5'.

DEVONIAN CONTACT
ls., purple, sdy.

DAYTON-MADISON SECTION, BIG HORN MOUNTAINS, WYOMING (Sheet 10 of 10)

Surface Section - Pahasapa Limestone

SPRING CREEK

Pennington County, South Dakota

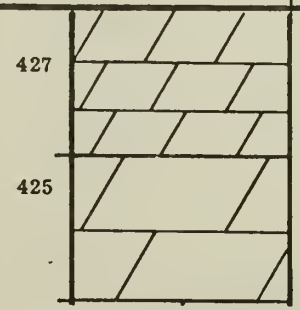
Section in SW 1/4, Sec. 6, T1S, R7E

on North wall of Canyon

Vertical Scale: 1" = 5' GARY SCHNEIDER

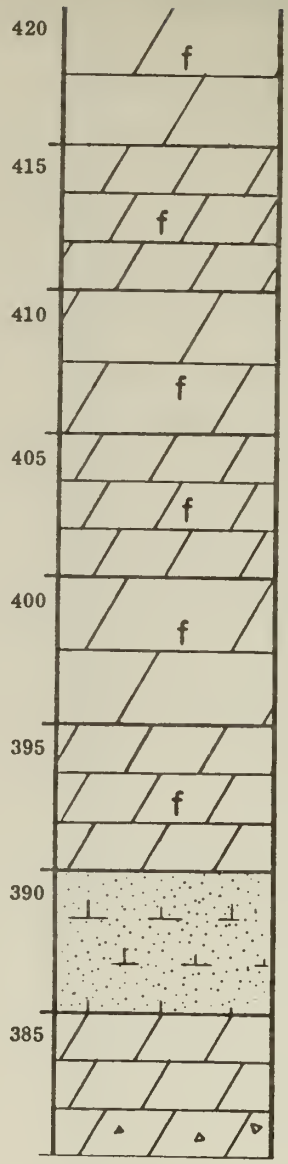
Dept. of Geol. & Geol. Eng., S.D.S.M.&T., 7/71

By J.C.M., J.P.G., D.C.B.



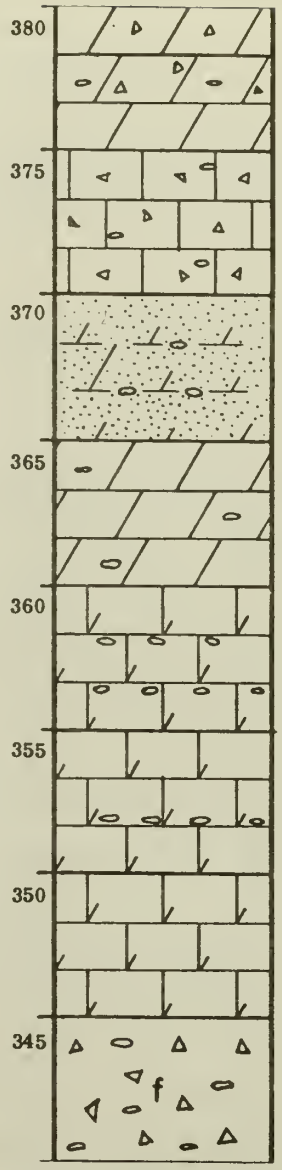
	% Dolo.	Grain Size	
			RED SOIL AND RUBBLE OF THE MINNELUSA
427	97	crs-mic.	SC Cp65: dolo., wh. and gry., 97% crs.-micro. xln. dolo., 1-2% med. xln. sparry calc. in vugs, 1% silica, disrupted or dismic., mottled, brecciated, argill., Fe stain, 6" beds, great variation in grn. size, heavy stain from above.
425	95	crs.-f	SC Cp64: dolo., tan, 95% fn.-crs. xln. dolo., 1-2% med.-fn. xln. calc. with some med. xln. sparry patches, 1-3% qtz. grns. and silica in pores, (wh. xls. and brn. cemt), pelletal?, patches and strgrs. fn. xln. dolo. and limon., intergran. and vuggy por., recryst., beds 2' - massive.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 1 of 12)



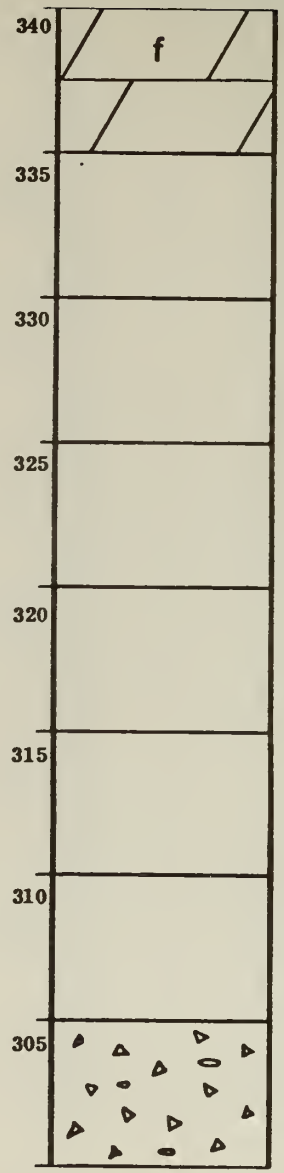
95	m-f	SC Cp63: dolo., gry.-tan, 95% med.-fn. xln. dolo., 1-2% med. xln. sparry calc. in patches, 2-3% qtz. sd. and some silica in pores, mottled ls. and dolo. in places, Syringapora-hex corals-brachs, argill., vuggy por., Fe stain, massive.
80	f	SC Cp62: dolo., brn., 80% fn. xln. dolo., 20% med.-fn. xln. intergran. calc. with a few med. xln. sparry patches, Syringapora, hex corals-brachs, argill., limon., "sdy".
98+	m-crs.	SC Cp61: dolo. Syringapora Zone, pk.-gry., 98+% med.-crs. xln. dolo., 1-2% med. sparry calc. in coral, massive Syringapora-hex corals-brachs, argill., minor silica, vuggy, Fe stain.
70	m-f	SC Cp60: dolo., pk.-wh., 70% med.-fn. xln. dolo., 30% med.-fn. xln. intergran. calc., massive Syringapora, brachs, argill., recryst., zones of vuggy por., Fe stain.
90	f	SC Cp59: dolo., tan, 90% fn. xln. dolo., 5% fn. xln. calc. and also in fracs. and vugs, some qtz. sd. and chert cemt., argill., poorly preser. brachs., Syringapora, mottled, Fe stain, beds 30" and up.
60	f	SC Cp58: dolo., pk. and gry., 60% fn. xln. dolo., 1-3% med. xln. sparry calc. in fracs and vugs, 30-40% qtz sand-silt, chert nod., some silica cemt., crinoids-horn corals-brachs, some vuggy por., limon. and hematite.
25	f	SC Cp57: carb. qtz. silt, tan, 40-50% fn. ang. qtz. silt, 25% fn. xln. dolo., 25% fn. xln. calc. cement, chert, argill., calc. veins, some silica cement, Fe stain, variable sd-cemt. ratio.
98	f-mic	SC Cp56: dolo., tan, 98% fn.-micro. xln. dolo., calc. frac. fill, contorted bedding, dessic. cracks, interclasts, fn. ang. qtz. grns., brecciated, slightly silicified, mang. grns. and dend., mang. carb., 4-6" beds.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 2 of 12)



90	f	SC Cp55: dolo., gry., 90% fn. xln. dolo., 10% fn.-mic. xln. calc. and sparry frac. fill cemt., some ls. breccia with chert, argill., frac. and sheared, slightly recryst., Fe stain, mang. grns. and mang. carb., 4-6" beds.
30	f	SC Cp54: brecciated ls., tan, 60-70% fn. xln. calc., 30% fn. xln. dolo., some chert, highly frac. and recemen. with calc. and limon., Fe stain.
30	f	SC Cp53: dolo. qtzite., tan, 60-70% qtz. silt, 30% fn. xln. dolo., few grns. calc., chert in 6" beds, some patches silica cement, argill., Fe stain, some crs. xln. calc.
80	mic.	SC Cp52: dolo., wh.-tan, 80% micro. xln. dolo., 20% med.-fn. xln. frac. fill calc., pellets?, argill., chert nods., highly frac. and recemen., Fe stain, some mang., 4-8" beds.
2	f	SC Cp51: ls., wh.-tan, 98% micro. xln. calc. and micrete lumps, 1-2% measled dolo. in lumps, abdt. chert in bands, some ang. qtz. grns., argill., sheared and frac., Fe stain, mang.
-	f-mic	SC Cp50: ls., light gry., predom. fn.-micro. xln. ls., pelletal?, highly siliceous-abdt. chert, sheared and jointed, stylolites, Fe stain, 8-12" beds.
30	f	SC Cp49: dolo. ls., wh.-gry., 60-70% fn. xln. calc., 30% fn. xln. dolo., pelletal., abdt. chert in strks. and bands, argill., zones of vuggy-spongy por., stylolotic fracs., recryst., Fe stain, mang. abdt. in strks. of grns., 6-12" beds.
-	-	SC Cp48: chert breccia, gry. and tan, 95% chert with evid. of pellets, lumps, and fossils, bands, fracs. recemen. with silica; 5% med.-fn. xln. calc. cement.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 3 of 12)



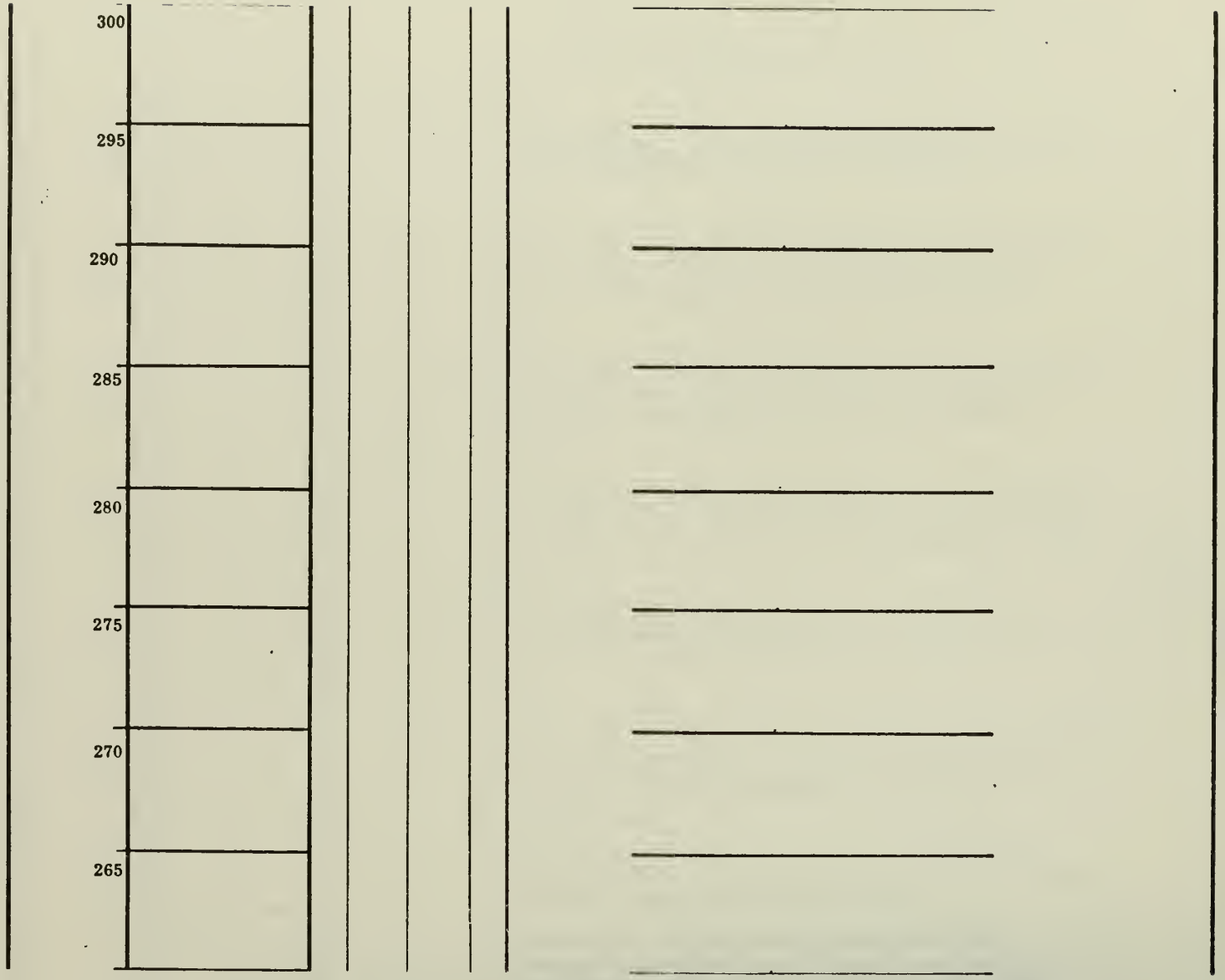
40 f

SC Cp47: dolo. ls., light gry., 60% fn. xln. calc., 40% fn. xln. dolo., lumps-pelletal?, fossil molds, slightly argill., recryst., some disem. silica, Fe stain, little mang., pp orange incl., 3-4' bed over and underlain by breccia.

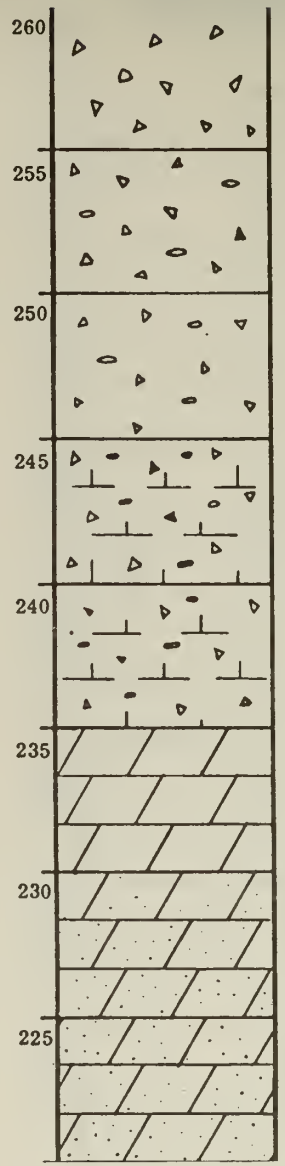
Covered.

Massive breccia zone - not sampled - cherty.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 4 of 12)

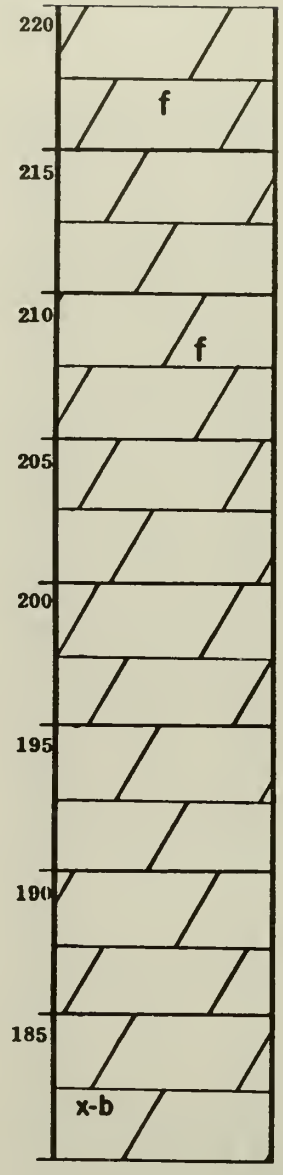


SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 5 of 12)



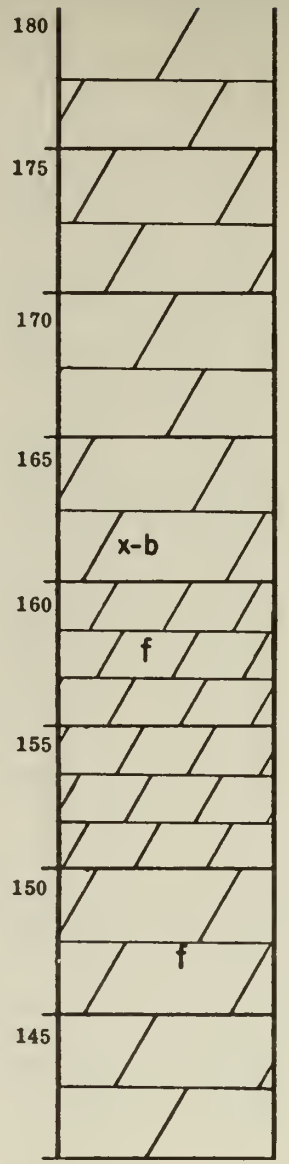
260	-	m-f	SC Cp46: breccia, pk.-tan, 50% med.-fn. xln. calc., 25-30% sub ang.-sub rounded qtz. matrix, 15-20% argill., chert grns. and pebbles, strks. of 90-100% qtz. grns., mold of pyrite cube, Fe stain, mang. grns. and strks.
255	-	-	SC Cp45: breccia, pk.-tan, crs.-fn. xln. calc., chert, dolo., drusy calc., argill., Fe stain, mang., friable.
250	-	-	SC Cp44: breccia, pk.-tan, predom. micrite with some fn. xln. calc., chert, qtz. grns. with rough surfaces, dolo. knobs in breccia, argill., stylolites, Fe stain, mang. grns., some vy friable and punky areas.
245	-	-	SC Cp43: ls.-chert breccia, pk.-tan, brecciated crs. xln. calc. and chert with chert to 2 cm nodules, argill., Fe stain, weathered.
240	25	f	SC Cp42: ls., breccia, pk-tan, 70% fn. xln. calc., 25% fn. xln. dolo., 4% qtz. grns. and silica frac. fill, pelletal., argill., breccia with brn.-gry. chert, recryst., Fe stain, mang. grns.
235	98	f	SC Cp41: dolo., light pk., 98% fn. xln. dolo., 1-2% fn. ang. qtz., banded-textural-mic.-fn. xln., color banding?, argill., mang. dend., hard.
230	65	f	SC Cp40: silty dolo., light pk., 65% fn. xln. dolo., 35% fn. ang. qtz., mang. grns., hard, 8-12" beds.
225	60	f	SC Cp39: silty dolo., pk.-tan, 60% fn. xln. dolo., 40% qtz. silt (ang.), some calc. recemen. fracs., few vugs, mang. grns., hard.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 6 of 12)



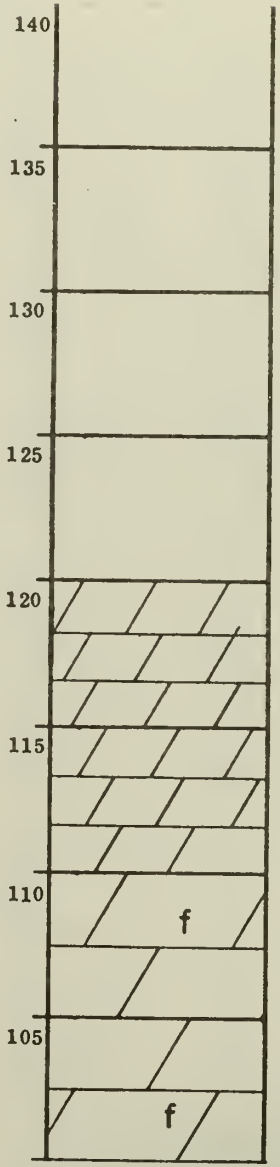
95+	f	SC Cp38: dolo., pk.-tan, 95+% fn. xln. dolo., 4% fn.-med. xln. frac. fill and fossil mold fill calc., pelletal., some color banding, few qtz. grns., zones of vuggy por. in bands, recryst., Fe stain, mang. grns. and dend. with mang. carb., massive.
95	f-vf	SC Cp37: dolo., wh.-tan, 95% fn.-vfn. xln. dolo., 2% med.-crs. xln. sparry calc. patches, 2-3% fn. qtz. grns., lumpy? pelletal?, recryst., mang. grns., massive.
98	f	SC Cp36: dolo., pk.-tan, 98% fn. xln. dolo., 1-2% fn. xln. calc. some in fossil molds, pelletal?, crinoid molds, argill., few fn. qtz. grns., vuggy-spongy por., recryst., Fe stain, mang. stain and grns., mang. carb., massive.
95	f-mic	SC Cp35: dolo., wh., 95% fn.-micro. xln. dolo., 5% fn.-micro. xln. frac. fill calc., dep. breccia zones, dolo. grns. floating in calc. frac. fill, Fe stain, some mang., massive.
95	f	SC Cp34: dolo., pk.-tan, 95% fn. xln. dolo., 5% med.-fn. xln. intergran. and frac. fill calc., argill., frac. and recemen., Fe stain, mang. grns., dense, massive.
98	f-vf	SC Cp33: dolo., pk.-gry., 98% fn.-vfn. xln. dolo., 1-2% fn.-vfn. xln. intergran. calc., lam., pelletal?, argill., patches of dolomic., sugary-sli. fri., mang. grns. and mang. carb., massive, med. hard.
98	m-f	SC Cp32: dolo., pk.-tan, 98% med.-fn. xln. dolo., 1-2% silica intergran. and in vugs, color bands, lam., x-bedding, recryst., Fe stain, pyrite?, mang. grns., massive, med. hard.
95	f	SC Cp31: dolo., gry.-tan, 95% fn. xln. dolo. (rhombs.), 5% fn. xln. intergran. calc., dolarenite, lam. with some x-bedding, argill., mang., massive.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 7 of 12)



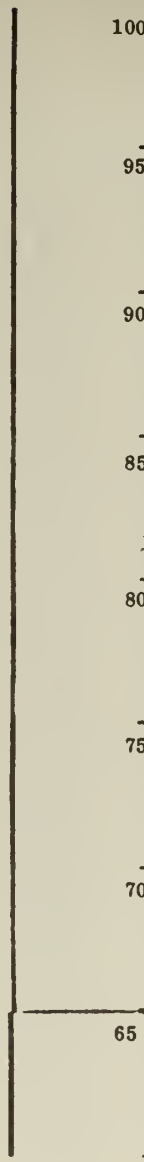
95	f-mic	SC Cp30: dolo., yel. tan, 95% fn. xln. dolo., 5% fn. xln. intergran. calc., argill., Fe stain, mang. grns., sugary, varies lat. from soln. breccia to massive with lam.
95	f	SC Cp29: dolo., pk.-tan, 95% fn. xln. dolo., 5% fn. xln. intergran. and med.-crs. sparry patches-frac. fill, calc., argill., stylolites, recryst., Fe stain, mang. grns., pyrite cubes on bedding planes, massive.
98+	f	SC Cp28: dolo., gry.-tan, 98+% fn. xln. dolo., 1-2% fn. xln. intergran. calc., argill., vuggy-spongy por., Fe stain, some mang., some Cu-Cr or ferric green stain?, pyrite cubes on bedding planes, massive, vy hard, some lam?
95	m-f	SC Cp27: dolo., pk.-tan, 95% med.-fn. xln. dolo., 2-3% fn. xln. intergran. calc. some lining vugs, pelletal., dismic., argill., vuggy-spongy por., Fe stain, massive with x-bedding in out crop.
97+	f-vf	SC Cp26: dolo., gry.-brn., 97+% fn. vfn. xln. dolo., 2-3% fn. xln. intergran. and sparry blebs calc., pelletal., crinoid frags.-few, few qtz grns., argill., jointed, Fe stain, little mang., mottled, 6-8" blocky beds.
99+	vf	SC Cp25: dolo., tan, 99+% vfn. xln. dolo., argill., few small qtz. grns. and blebs, jointed, Fe stain, mang., 6-8" blocky beds.
70	f	SC Cp24: dolo., tan, 70% fn. xln. dolo., 25-30% sparry med.-fn. xln. intergran. and frac. and vug fill calc., pelletal, dismic., fossil, slightly argill., vuggy-spongy por., stylolites, recryst., Fe stain - pyrite? - cubes, some mang., 3-4' beds.
99+	f-vf	SC Cp23: dolo., gry.-tan, 99+% fn.-vfn. xln. dolo., argill., limon. or hematite after pyrite, mang. dend. and grns., 3-4' beds, cliff.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 8 of 12)



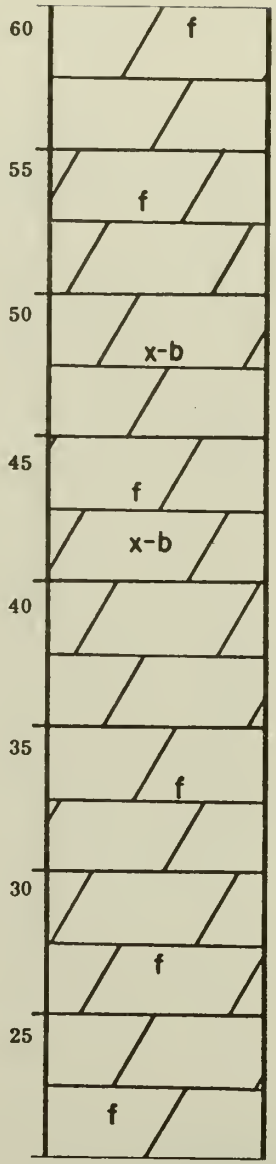
		Covered interval - grassy slope.
120	98	f	SC Cp22: dolo., wh.-tan, 98% fn. xln. dolo., 1-2" fn. xln. calc., pelletal?, frac'd., slightly vuggy-spongy por., soln. features "breccia", recryst., limon. stain., slabby bedding.
115	90+	f-vf	SC Cp21: dolo., gry.-tan, 99+% fn. xln. dolo., 1+% fn. xln. intergran. calc., irreg. wavy fracs.-recemen., slightly vuggy-spongy por., limon. and hematite stain, hard.
110	90+	f-vf	SC Cp20: dolo., gry., 90% fn.-vfn. xln. dolo., 10% med. xln. sparry calc. in fossil molds etc., pelletal-interclastic, fossil frags. and replac., argill., some vuggy-spongy por. zones, limon. and hematite, med. hard, 1-2' beds.
105	95+	f	SC Cp19: dolo., pk.-tan, 95+% fn. xln. dolo., 5% crs. xln. sparry calc. frac. fill, pelletal, fossil molds, slightly argill., frac., spongy por., recryst., some limon., mang. and mang. carb., vy hard, TOP OF FIRST MASSIVE CLIFF BENCH.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 9 of 12)



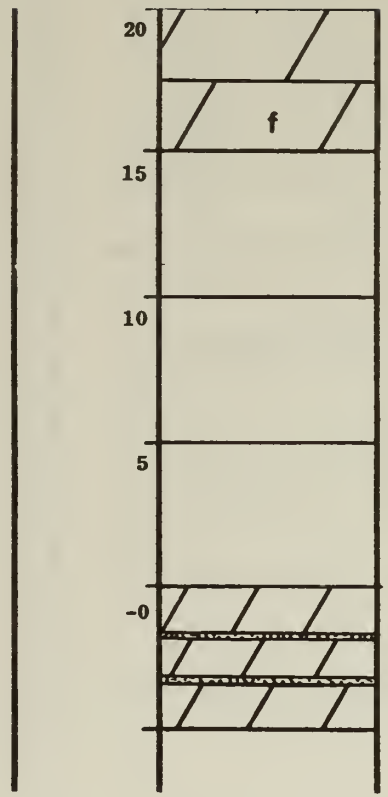
99+	f	SC Cp18: dolo., pk.-tan, 99+% fn. xln. dolo., 1% fn.-med. xln. vug fill. calc., fossil molds, slightly argill., frac., vuggy por., recryst., some mang., vy hard.
95+	f	SC Cp17: dolo., gry.-tan, 95+% fn. xln. dolo., 3-5% med.-crs. xln. sparry calc. frac. fill., pelletal?, fracs., vuggy-spongy por., recryst., some limon., mang. grns., some 4" beds, vy hard, still cliff.
99+	f	SC Cp16: dolo., gry.-tan, 99+% fn. xln. dolo., 1% med-fn. xln. calc. in molds and vugs, slightly argill., crinoid molds, vuggy por., frac. and jointed, "hackley", recryst., mang., vy hard.
98+	f	SC Cp15: dolo., tan-brn., 98+% fn. xln. dolo., 1-2% med.-fn. xln. calc. mainly in vugs, argill., silica nod. to 5-10 mm. and some intergran., fracs. and joints, some vugs, recryst., some limon. stain., mang. grns., vy hard.
98+	f	SC Cp14: dolo., gry.-tan, 98+% fn. xln. dolo., 1-2% mod.-fn xln. calc. with some mcd. xln. sparry patches, argill., few vugs, recryst., slightly limon. stain, mang. grns., evid. of sol. and refill, sol. zone at 79', weaths. gry.
98+	f	SC Cp13: dolo., pk.-tan, 98+% fn. xln. dolo., 1-2% fn.-crs. xln. sparry calc., pelletal., fossil molds, argill., vuggy por., recryst., some limon., 4' beds.
98+	f	SC Cp12: dolo., pk.-tan, 98+% fn. xln. dolo., 1-2% med.-fn. xln. calc., joints, some vugs, recryst., some silica lining vugs, little limon., mang. grns., 3-4' beds, cliff.
98	f	SC Cp11: dolo., pk.-tan, 98% fn. xln. dolo., 1-2% sparry med. xln. calc., fossil molds, jointed, vuggy, recryst., some limon. stain, massive, cliff former.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 10 of 12)



97+	f	SC Cp10: dolo., tan-brn., 97+% fn. xln. dolo., 2-3% fn. xln. calc., pelletal?, fossil?, argill., vuggy por., recryst., limon. stain, 3' - massive beds, cliff, weaths. gry.
98	f	SC Cp9: dolo., tan, 98% fn. xln. dolo., 1-2% med.-fn. xln. calc. with some med. sparry patches, few fossil molds, vuggy-spongy por., recryst., limon. stain., mang. grns. some slabby beds and recemen. joints, cliff former, med. hard.
97+	f-m	SC Cp8: dolo., lt. pk.-tan, 97+% fn.-med. xln. dolo., 2-3% fn. xln. and some fn.-med. calc. measled dolo., slightly laminated, argill., vuggy-spongy, recryst., mang. grns., massive - 3' beds, some x-bedding on outcrop.
95	f-m	SC Cp7: dolo., gry.-tan, 95% med.-fn. xln. dolo., 4-5% fn. xln. and med.-crs. sparry calc., pelletal?, some recryst. fossil and molds, some vuggy por., joints, mang. dend. and grns., massive, cliff former, vy hard.
98+	f	SC Cp6: dolo., gry.-tan, 98+% fn. xln. dolo., 1+% fn. xln. calc., some vugs, jointed, recryst., some mang., some limon., massive, cliff, vy hard.
98+	f	SC Cp5: dolo., gry.-brn., 98+% fn. xln. dolo., 1-2% med.-fn. xln. calc., fossil molds, vugs, recemen. joints, recryst., mang. dend., massive, cliff former, hard.
98	mic.-f	SC Cp4: dolo., buff gry.-brn., 98% mic.-fn. xln. dolo., 1-2% fn.-med. xln. calc. fossil molds-crinoids, argill., vugs, spongy zones, recemen. joints, recryst., mang., limon. stain, massive, cliff.
98+	mic.-f	SC Cp3: dolo., buff gry.-brn., 98+% mic.-fn. xln. dolo., 1-2% med. xln. calc., fossil molds, argill., vuggy, some fn. joints, recryst., limon. stain, massive bedded, cliff.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 11 of 12)



98+	mic.-f	SC Cp2: dolo., gry.-brn., 98+% fn. xln.-mic. dolo., little med.-fn. xln. calc., pelletal?, fossil molds, slightly argill., vugs, spongy, recryst., limon. stain, massive bedded, cliff former.
		Covered talus slope.
98	f	SC Cel: dolo., ppl.-pk., 98% fn. xln. dolo., 1-2% fn. silt, argill., limon. stain., mottled, slightly x-bedded (micro), rubbley and thin bedded with few 1 ft. beds, interbedded with siltstones.

SPRING CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 12 of 12)

Surface Section - Pahasapa Limestone

DARK CANYON

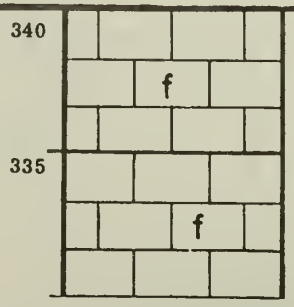
Pennington County, South Dakota

N1/2, SE1/4, NW1/4, Sec. 13, T1N, R6E

Vertical Scale: .1" = 5'

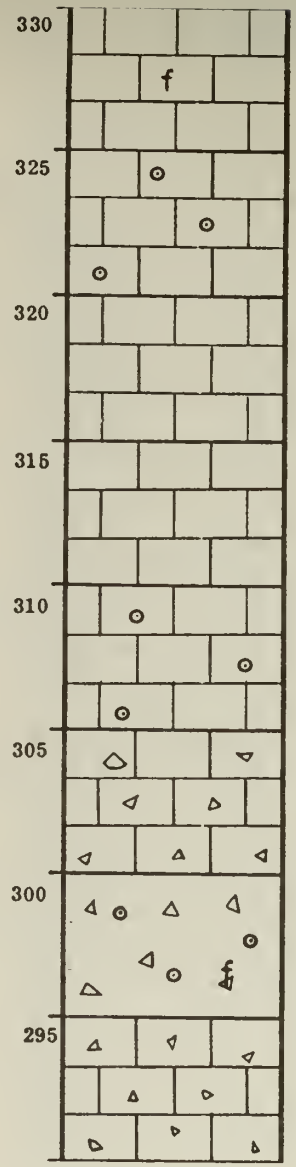
Dept. of Geol. & Geol. Eng., S.D.S.M. & T., 7/71

GARY SCHNEIDER 5/73 PLATE 2



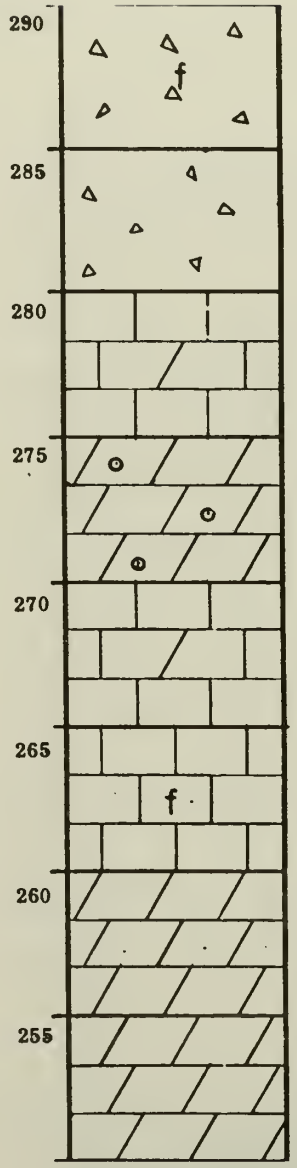
	% Dolo.	Grain Size	
340	0	f	2016: ls., fn. xln.-mic. Some silica blebs. Pelletal, interclastic. Brachs, crinoids, etc. Fe stain.
335	0	m-f	2015: ls., med.-fn. xln. Some silica blebs. Pelletal, interclastic. Argill. Fossiliferous. Moderate intergranular porosity. Fe stain.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 1 of 10)



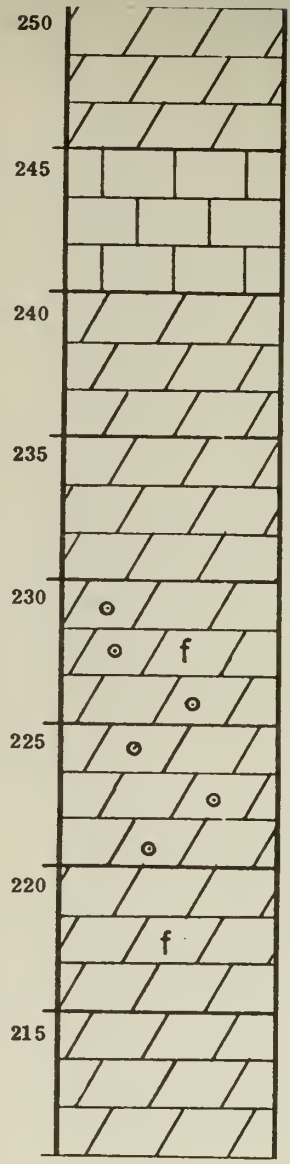
0	mi	2014: ls., mic. Minor silica. Pelletal, interclastic. Forams? Recemented fractures. Some Mn. gns. Fe stain.
0	mi-m	2013: ls., mic. with med. xln. calc. xls. 1-2% silica. Pelletal-oölitic. Recryst. Mang. dendrites. Fe stain. Recemented fractures.
0	mi-m	2012: ls., mic., with med. xln. calc. xls, Pelletal. 1-2% silica. Recryst. Recemented fractures. Fe stain - pyrite. Mang. dends.
0	f-m	2011: ls., fn.-med. xln. calcarenite. Some gns. sub-rounded. 5% chert gns. some sub-rnd. Pelletal? Fe stain.
0	f	2010: ls., fn. xln. 1-2% silica. Oölitic. Recryst. Slight mang. Slight Fe stain.
0	-	2009: ls. breccia. Fracture zone- med-crs. xln. calc. with 1-2% chert. Fractured. Fe stain-pyrite.
25	-	2008: chert breccia. 50% dis. chert, 25% crs.-fn. dolo., 25% med. xln. calc. Slightly argill. Oölitic? Fossil traces in chert.
0	-	2008: ls. breccia. 95% crs. xln. calc. Chert fragments to 1/2 cm.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 2 of 10)



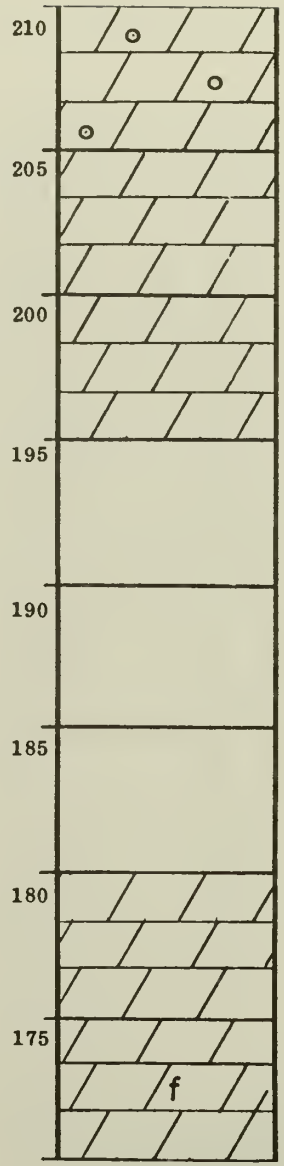
0	-	2006: chert breccia. Calc. cemented chert. Chert contains pellets, lumps, fossils, etc. Some drusy qtz. Fe stain.
0	-	2005: Same as 2006.
20	m	2004: ls., dolomitic. 80% med. xln. calc., 20% med.-fn. xln. dolo. Some intergran. sil. Pelletal? Argill. Recryst. Some mang. Fe stain - pyrite.
95	f	2003: dolo., 95% fn. xln., 5% fn. xln. calc. Oölitic, x-laminated. Some blebs of dolomicrite. Recryst. Vuggy porosity. Mang. gns. Fe stain-pyrite.
40	m-f	2002: ls., dolomitic. 60% med. xln. - crs. calc., 40% med. xln. dolo. Slight disrupted texture. Recryst. Fe stain and blebs - pyrite.
0	f-mi	2001: ls., fn. xln. - mic. Pelletal. Brachs. Few silica blebs. Vuggy porosity. Fe stain.
80	m-f	2000: dolo., calcareous. 80% med. - fn. xln. dolo., 20% med.-fn. xln. intergranular calc. Pelletal. Slight amount of silica. Argill. Recryst. Intergranular porosity. Mang. dendrites. Fe stain.
100	f-vf	1999: dolo., fn. - microxln. Laminated - cut and fill. Argill. Turbidite? Mang. gns.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 3 of 10)



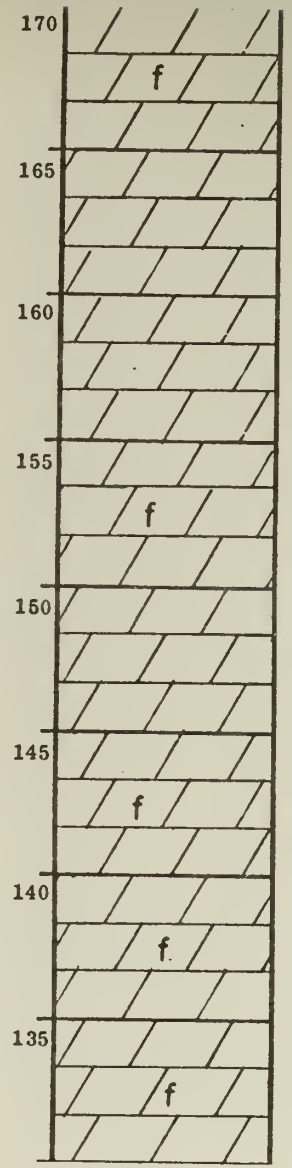
80	f	1998: dolo., 80% fn. xln. dolo., 20% fn. xln. calc. 1-2% silica gns. Argill. Slight disruptive bedding. Slight vuggy porosity. Mang. gns.
20	f	1997: ls., 80% fn. xln. calc., 20% fn. xln. dolo. Little silica. Argill. Recryst. Mang. gns. and dendrites.
98	f-vf	1996: dolo., 98% fn.-very fn. xln. dolo., 1-2% fn. - very fn. calc. Slightly laminated. 1% ± mang. gns. Fe stain - pyrite.
60	f-mi	1995: dolo., calcareous. 60% fn. - mic. dolo., 40% fn. xln. calc. Pelletal, dismic. Cross-bedded. Argill. Recryst. Mang. gns.
90	f-vf	1994: dolo. 90% fn. - very fn. xln. dolo., 10% fn. - med. xln. calc. blebs and infill. Argill. Some blebs of dolomicrinte. Oölitic. Vuggy-spongy porosity. Fossil hash. Mang. gns. Fe stain. Recryst. Calc. recemt. fracts.
95	f-m	1993: dolo. 95% fn.-med. xln. dolo., 5% fn. med. xln. calc. Oölitic. Some patches of dolomicrite. Recryst. Vuggy-spongy porosity. Mang. gns.
80	f-m	1992: dolo., calcareous. 80% fn.-med. xln. dolo., 20% fn. intergranular calc. Some silica blebs. Fossil frags. Pelletal? Recryst. Mang. gns. Fe stain.
98	f	1991: dolo., 98% fn. xln. - mic. dolo., 2% fn. intergranular and crs. patches and infill calc. Argill. Flat-pebble interclasts. Laminated-banded. Some vuggy porosity. Some mang. Fe stain. Stylolites-bedding plane.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 4 of 10)



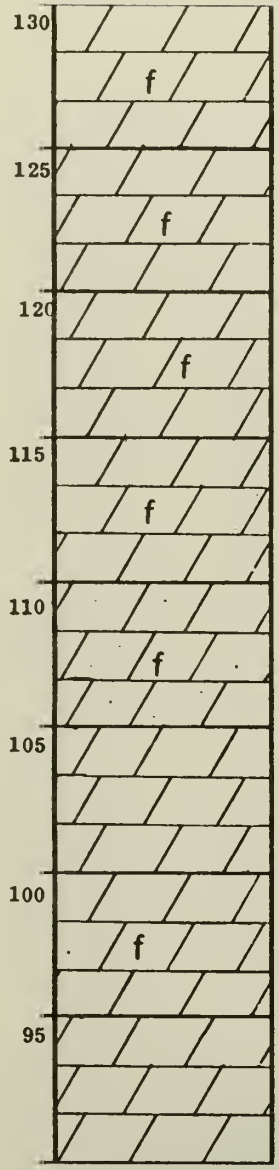
210	85	f	1990: dolo. 85% fn. xln. dolo., 15% fn. xln. calc. Some chert. Slightly argill. Laminated-banded. Pelletal-oolitic. Recryst. Fe stain.
205	80	m-f	1989: dolo., calcareous. 80% med.-fn. xln. dolo., 20% med. and some fn. xln. intergranular calc. Argill. slight silica. Some streaks of mang. Small blebs of Fe - probably pyrite.
200	95	m-f	1988: dolo. 95% med.-fn. xln. dolo., 5% med.-fn. xln. intergranular calc. Little silica. Laminations and x-lams. Vuggy zones // to laminations. Recryst.
195	-	-	Covered. No sample.
190	-	-	Covered. No sample.
185	-	-	Covered. No sample.
180	95	f	1987: dolo., 95% fn. xln. dolo., 5% med.-fn. xln. calc. and some crs. blebs. Slightly argill. Laminated-banded. Recryst. Some zones of fn. vuggy porosity. Fe stain.
175	95	f	1986: dolo., 95% fn. xln. dolo., 5% fn. xln. intergranular calc. Little silica around pores. Laminated-cut and fill. Zones of fossil molds and vuggy porosity. Stylolites. Fe stain.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 5 of 10)



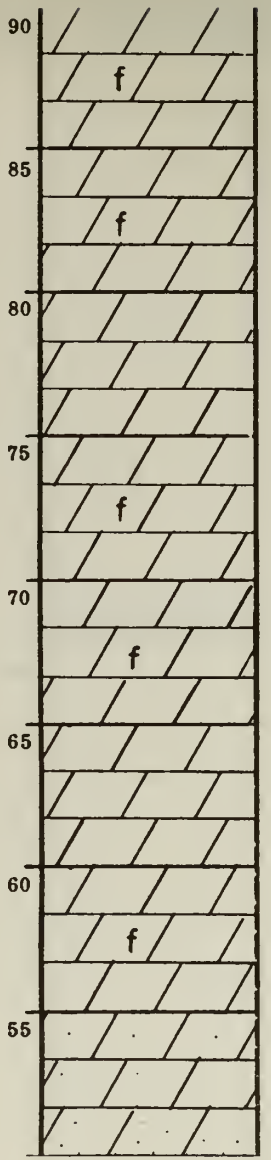
90	f	1985: dolo. 90% fn. xln. dolo., 10% fn. xln. calc. and fossil in fill. Argill. Some silica. Recryst. Fossil molds-vuggy porosity. Stylolite zone. Fe stain.
98	f	1984: dolo. 98% fn. xln. dolo., 2% fn. xln. calc. Argillaceous. Recrystallized. Some mang.
95	f	1938: dolo. 95% fn. xln. dolo., 5% fn. xln. and crs. blebs calc. Some silica. Argill. Recrystallized. Slight vuggy porosity.
95	f	1982: dolo. 95% fn. xln. dolo., 5% fn. xln. and crs.-med., blebs calc. Argillaceous. Some fossil molds-vuggy porosity. Recryst. Mang. gns.
98	f	1981: dolo., 98% fn. xln. dolo. Few blebs of dolomicrite. Slightly argillaceous. Slight mang. Recryst.
98	f	1980: dolo., 98% fn. xln. dolo., 1-2% fn. xln. intergranular calc. Argill. Pelletal. Few fossil molds-vuggy porosity. Recrystal. Little mang. Slight Fe stain.
98	f	1979: dolo. 98% fn. xln., dolo., 1-2% fn. xln. calc. and few med. xln. blebs. Argill. Few fossil molds-vuggy porosity, some with crs. xln. calc. in fill. Recryst. Fe stain.
98	f	1978: dolo., fn. xln. dolo., 1-2% fn. xln. intergranular calc. Argillaceous. Disrupted bedding. Fossil molds-vuggy porosity. "Reefoid". Recrystallized. Fe stain.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 6 of 10)



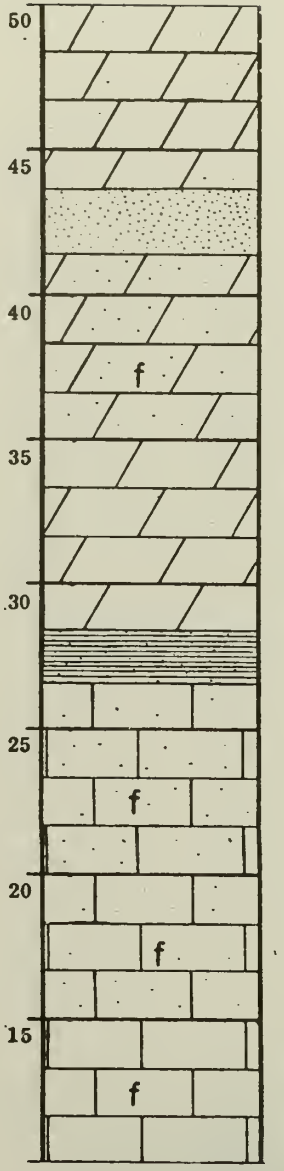
98	f	1977: dolo; 98% fn. xln. dolo., 1-2% fn. xln. intergranular calc. Argill. Disrupted bedding. Fossil molds-vuggy porosity. "Reefoid". Recrystallized. Fe stain.
98	f	1976: dolo., 98% fn. xln. dolo., 1-2% fn. xln. calc. Argill. Pelletal. Disrupted bedding. "Reefoid". Fossil molds, crinoids-vuggy porosity. Recrystallized. Fe stain.
95	f	1975: dolo. 95% fn. xln. dolo., 5% med.-fn. xln. calc. Argill. Some fossil molds, crinoids - vuggy porosity. "Reefoid". Recryst. Fe stain - pyrite. Some mang.
98	f	1974: dolo., 98% fn. xln. dolo., 1-2% fn. xln. calc. Slight silica. Fossil molds, crinoids - vuggy porosity. Pelletal, Recryst. Some mang.
95	f	1973: dolo., 95% fn. xln. dolo., 1-2% fn. xln. intergranular calc. 3-4% silica gns. Argill. Fossil molds-vuggy porosity. Recryst. Fe stain.
98	f	1972: dolo., 98% fn. xln. sacc. dolo., 1-2% fn. xln. intergranular calc. Argill. Pelletal. Banded. Recryst. Slight vuggy porosity. Stylolites. Fe stain.
95	f	1971: dolo., 95% fn. xln. dolo., 3-5% fn. xln. intergranular calc. Fossil molds-vuggy porosity. Recrystallized. Fe stain.
95	f	1970: dolo., 95% fn. xln. dolo., 1-2% fn. xln. intergranular calc. Argill. Minor silica. Distorted bedding. Recrystallized. Zones of vuggy-spongy porosity. "Reefoid".

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 7 of 10)



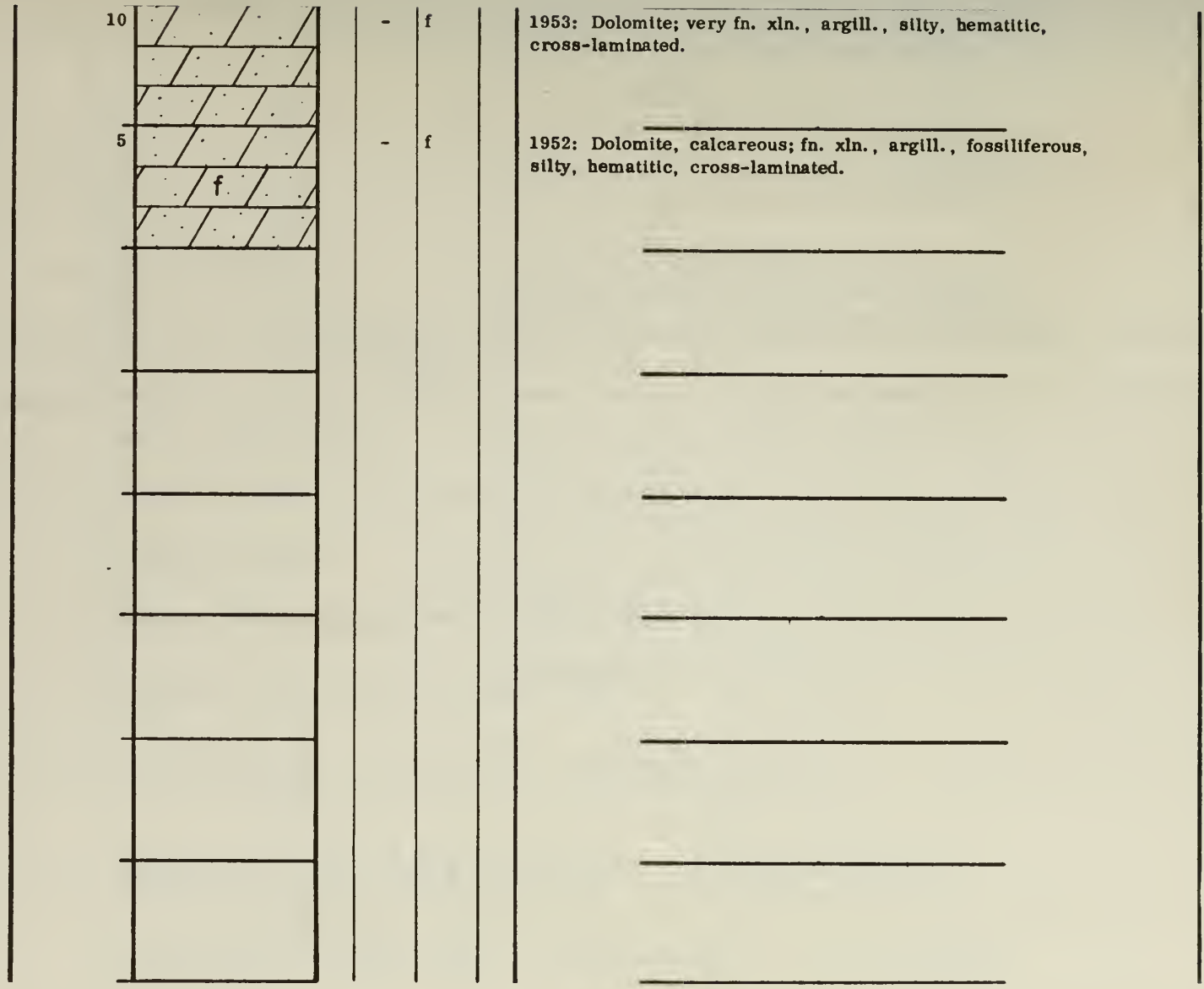
98	f	1969: dolo., 98% fn., xln. dolo., 1-2% fn. xln. calc. Argill. Fossil molds-vuggy porosity. Bioturbidite? Recryst. Fe stain.
95	f	1968: dolo., 95% fn. xln. dolo., 5% fn. xln. intergranular calc. Argill. Bioturbidite? Fossil mods-vuggy porosity. Recryst. Fe stain.
95	f	1967: dolo. 95% fn. xln. dolo., 5% fn. xln. calc. Slightly laminated. Recryst. Zones of vuggy porosity.
90	f	1966: dolo. 90% fn. xln. dolo., 10% fn. xln. intergranular calc. Slightly laminated. Fossil molds-vuggy porosity. Blocky fracture. Fe stain - pyrite.
90	f	1965: dolo. 90% fn. xln. dolo., 10% fn. xln. calc. Small fossil molds, brachs, corals, crinoids. Recrystallized. Vuggy porosity.
95	f	1964: dolo. 95% fn. xln. dolo., 5% med. xln. and fn. intergranular calc. Argillaceous. Finely laminated. Intergranular porosity. Fe stain.
95	f	1963: dolo., 95% fn. xln. dolo., 2-3% fn. xln. calc. 1-2% silica. Laminated. Argillaceous. Fossil molds filled with sparry calcite. Vuggy porosity.
80	f	1962: dolo. 80% fn. xln. dolo., 15% med. xln. and fn. xln. intergranular calc. 5% silica gns, some to 1 mm and rounded. Argill. Hematitic. Color change from yellows and browns to reds - Englewood? - below.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 8 of 10)



-	f	1961: Dolomite; fn. xln., very argill., silty, hematitic, cross-laminated.
-	-	1960: siltstone, qtz., argill., hematitic, slightly calc., cross-laminated.
-	f	1959: Dolomite; fn. xln., argill., hematitic, silty, slightly calc., cross-laminated, micro-fossils.
-	f	1958: dolomite; fn. xln., argill., hematitic, slightly calc., cross-laminated, some micro-hash.
-	-	1957: Claystone; calc., silty, slightly dolomitic, cross-laminated, hematite blebs and streaks.
-	f	1956: Limestone; argill., silty, fossiliferous, some hematite blebs, dolomitic, cross-lam.
-	f	1955: Limestone; fn. xln., argill., hematitic, some silica gns., cross-laminated, small-micro fossils.
-	f	1954: Limestone; fn. xln., argill., hematitic, fossiliferous, cross-laminated.

DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 9 of 10)



DARK CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 10 of 10)

Surface Section - Pahasapa Limestone

WHITEWOOD CREEK

Lawrence County, South Dakota

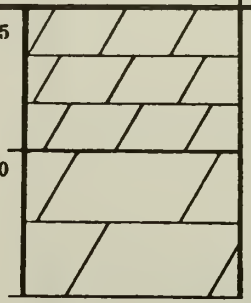
Section in SE 1/4, SE 1/4, Sec. 1, T5N, R3E

North bank of Whitewood Creek - cliff

Vertical scale: 1" = 5'

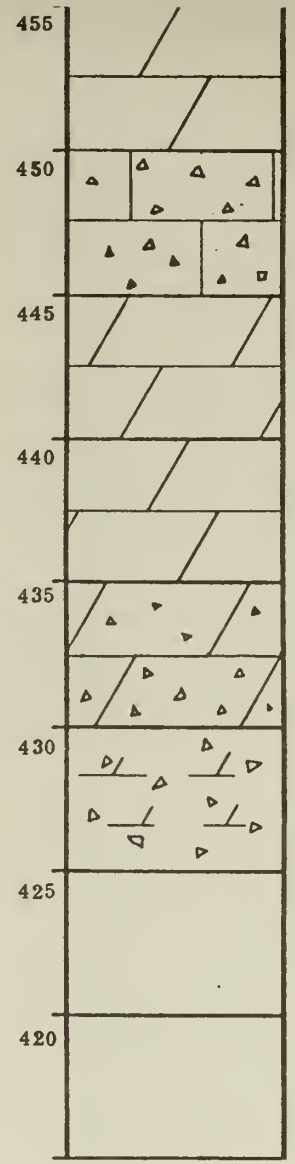
Dept. of Geol. & Geol. Eng., S.D.S.M. & T. 7/71

By: J.C.M., D.C.B.



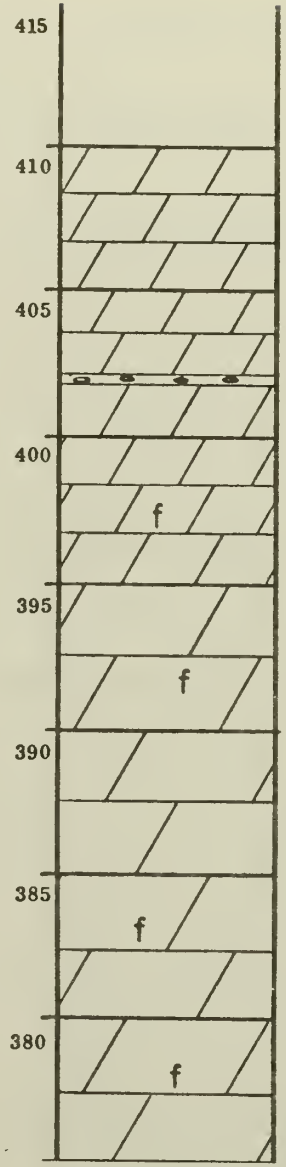
	% Dolo.	Grain Size	
465	98	m	WhC Cp89: dolo., pk.-yel.,-brn., 98% med. xln. dolo., some med. xln. sparry calc. and some in recemen. fracs., slightly argill., intergran. por., some silica in vugs, Fe stain, 8-10" beds.
460	65	m	WhC Cp88: dolo., pk.-brn.-yel., 65% med. xln. dolo., 35% med. xln. calc. and sparry med. xln. calc. in fracs., mottled, brecciated, argill., intergran. por., some vuggy por., some silica, mang. grns. and in fracs., massive beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 1 of 14)



60	m	WhC Cp87: dolo., pk.-brn.-yel., 60% med. xln. dolo., 40% crs.-med. xln. calc., mottled, brecciated, clay, lots of mang., massive.
20	crs-m	WhC Cp86: ls. breccia, pk.-brn.-yel., 80% crs.-med. xln. calc., 20% crs.-med. xln. dolo., argill., intergran. por., some qtz. grns. and intergran. silica, limon., mang., massive bed.
80	m	WhC Cp85: dolo., yel.-brn., 80% med. xln. dolo. some rhomb., 20% med. xln. calc. in frac. and fn.-med. xln. calc. intergran., pelletal? argill., fracs. and joints, some vuggy and intergran. por., recryst., mang., massive beds, weaths. gry-brn.
75	f	WhC Cp84: dolo., brn.-pk., 75% fn. xln. dolo., 25% sparry med. xln. calc. and fn. xln. intergran. calc., mottled, intergran. por., Fe stain, mang. dend. and grns., massive beds, weaths. gry.-brn., crumbly-punky rounded surface.
95	m-f	WhC Cp83: dolo. breccia, pk.-brn.-yel., 95% med.-fn. xln. dolo., 2-3% crs. sparry calc. in stringers and blebs, mottled, slightly argill., veins and joint, zones of vuggy por., some chert, some limon., some mang., massive, weaths., brn.-pk., some areas vy limey.
75	f	WhC C82: breccia, yel.-brn.-pk., 75% fn. xln. dolo., 25% sparry crs. xln. calc. in recemen. fracs., fracs. and joints, limon.
		Covered.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 2 of 14)



410	99	f
405	98	f
400	99	f
395	99	f
390	85	m
385	98	f
380	95+	f-vf

WhC Cp81: dolo., light yel.-brn., 99% fn. xln. dolo. with some rhombs., intergran. por., minor silica in vugs, Fe stain, some mang., weaths. gry.-buff, friable.

WhC Cp80: dolo., yel.-buff, 98% fn. xln. rhombic dolo., blebs or bands of micrite, stringers of silica, 4" brn. chert bed at 402', recryst., Fe stain, weaths. gry.-buff, vy friable.

WhC Cp79: dolo., gry.-wh., 99% fn. xln. rhombic dolo., occ. vfn. xln. pellet, vuggy-intergran. por., some mang., vy friable-mealy, covered steplike outcrop in 6" beds, few fossils?

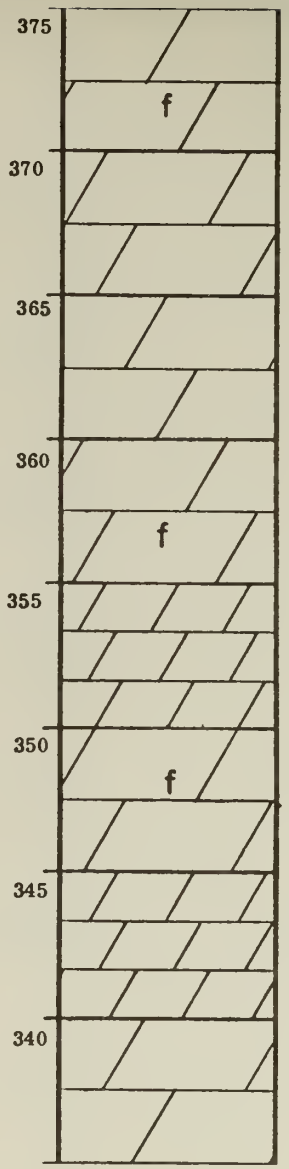
WhC Cp78: dolo., buff brn., 99% fn. xln. dolo., pelletal., fossil molds, argill., vuggy-spongy por., some limon., mang., weaths. pk.-buff, 8-18" beds, TOP OF CLIFF.

WhC Cp77: dolo., gry.-pk., 85% med. xln. dolo., 15% intergran. silica cement med.-fn. xln. with many euhedral surfaces, mang., hard, dense, 2-3' beds.

WhC Cp76: dolo., pk.-brn., 98% fn. xln. dolo., fossil molds, slightly lam., vuggy por., mang. dend. and grns., loose, friable, 2-3' beds.

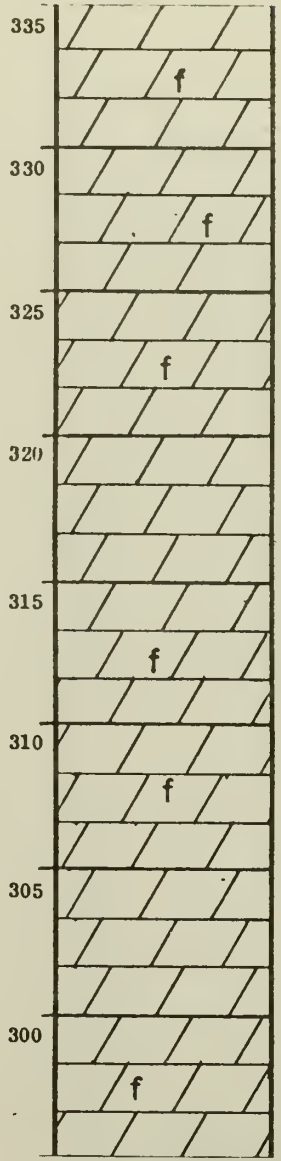
WhC Cp75: dolo., pk.-buff, 95+% fn.-vfn. xln. dolo., 1-2% fn. xln. intergran. calc., fossil molds, vuggy-intergran. por., slight silica, Fe stain, little mang., weaths. gry., 1-2' beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 3 of 14)



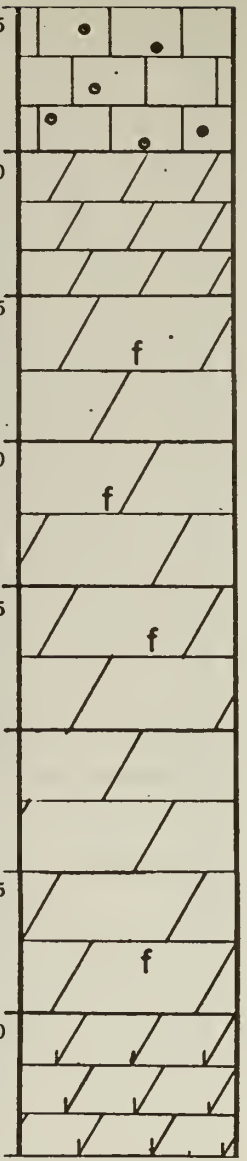
80	f	WhC Cp74: dolo., pk.-brn.-gry-buff, 80% fn. xln. dolo., 10-20% med. xln. sparry calc., 0-10% silica with some grns., blebs of dolo., 2-3 mm with med. xln. calc., burrow? fossil molds-crinoids, alt. bands of color, 12-18" beds.
80	vf	WhC Cp73: dolo., brn.-pk., 80% vfn. xln. dolo., 20% silica, distorted bedding - bioturb. ?, slight argill., recryst., dense, hard, conch. frac., 2-3' beds.
98	f	WhC Cp72: dolo., cream-light brn., 98% fn. xln. dolo., 2% sparry med. xln. calc. in vugs and fn. xln. intergran., fossil molds, slight argill., vuggy por., tubules? and pockets, abdt. calc. fill, Fe stain, mang., friable, 2-3' beds.
95	f-mic	WhC Cp71: dolo., pk.-brn., 95% fn.-micro. xln. dolo., 1-2% sparry med. xln. calc. and lining vugs, 1-2% mang. dend. and grns., fossil molds, slight argill., calc. tube fill?, Fe stain, dense, 12-18" beds, weaths. brn.-buff.
80	vf	WhC Cp70: dolo., banded pk.-brn. and gry.-buff, 80% vfn. xln. dolo., 20% silica, slight argill., few pp pores mang. dend. and grns., hard dense, 2-6" beds, cliff.
95	f	WhC Cp69: dolo., yel.-buff, 95% fn. xln. dolo., 5% sparry crs. xln. calc. in vugs. and fracs., fossil molds, vuggy por., recryst., recemen. fracs., Fe stain, mang., 12" beds, weaths. gry.-buff.
58	m	WhC Cp68: calc. dolo., pk.-gry., 58% med. xln. partially rhombic dolo., 40% sparry med. xln. calc., distorted bedding-bioturbidite, micrite pellets, argill., Fe stain, mang. dend., up to 1-2% weaths. gry.-buff, 6-12" beds
50	f	WhC Cp67: calc. dolo., pk.-brn., 50% fn. xln. anhedral dolo., 50% fn. xln. calc. with some sparry calc., pelletal?, blebs, argill., fracs recemen. with calc., recryst., Fe stain, mang. dend. and grns., 12" bed on 8-10' cliff.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 4 of 14)



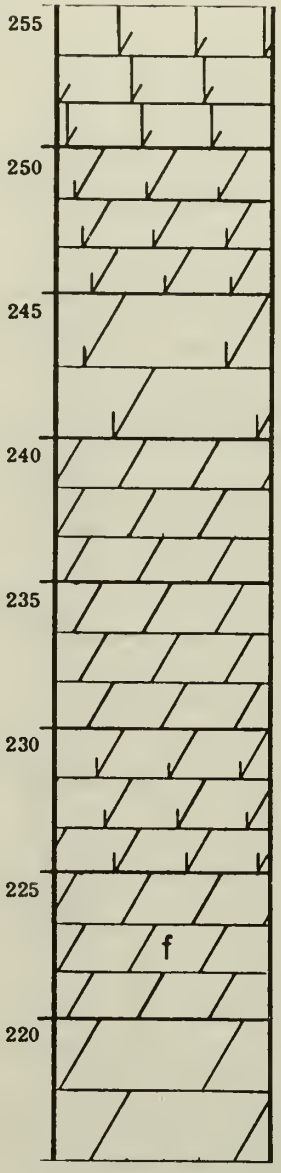
60	f	WhC Cp66: calc. dolo., pk.-brn., 60% fn. xln. dolo., 40% fn. xln. intergran. and sparry calc., oolitic-pelletal, fossil hash, some vuggy zones, some recemen. fracs. with sparry calc., recryst., locally more ls. than dolo.
50	f	WhC Cp65: calc. dolo., pk.-light brn., 50% fn. xln. dolo., 50% fn. xln. intergran. and some sparry calc., fossil relics, recryst., Fe stain, some mang., sugary, dense, weaths. gry.-buff, hard.
50	f	WhC Cp64: calc. dolo., gry.-wh., 50% fn. xln. anhedral dolo., 50% fn. xln. intergran. and some sparry calc., pelletal-lump?, fossil relics, chert and silica with some grns., frac.-recemen. recryst., Fe stain, hard, dense, 6-12" beds, weaths. cream-buff.
45	f	WhC Cp63: dolo. chert, brn., 45% fn. xln. dolo., 5% calc., 40-50% silica in chert and stringers, pelletal-lump?, argill., recryst., Fe stain, mang. dend. and grns., hard, dense, weaths. gry.-brn., 4-6" beds.
95	f	WhC Cp62: dolo., light brn. with pk. cast, 95% fn. xln. dolo., 5% crs. sparry calc. and some intergran. calc., lam. and x-lam., recryst. crinoids, some zones of vuggy por., pk. strks. and bands, calc. vug fill, some silica, mang. grns. parallel to lams. in places, dense, 6-12" beds.
98	f	WhC Cp61: dolo., light brn., 98% fn. xln. dolo., 1-2% fn. xln. intergran. calc., coral?, filled worm like borings, "spaghetti rx", argill., intergran. por., recryst. ?, dense, powdery when struck, 6-12" beds.
98	f	WhC Cp60: dolo., light brn., 98% fn. xln. dolo., laminated, nodules, argill., intergran. por. and some areas of vuggy por., little Fe stain, few mang. dend. and grns., weaths. gry.-wh., dense, 4-6" beds.
98	vfn-mic	WhC Cp59: dolo., brn., 98% vfn.-micro. xln. dolo., recryst. coral or disturbed bedding?, some vuggy por., little Fe stain, few mang. dend. and grns., weaths., gry.-wh., dense, 4-5" beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 5 of 14)



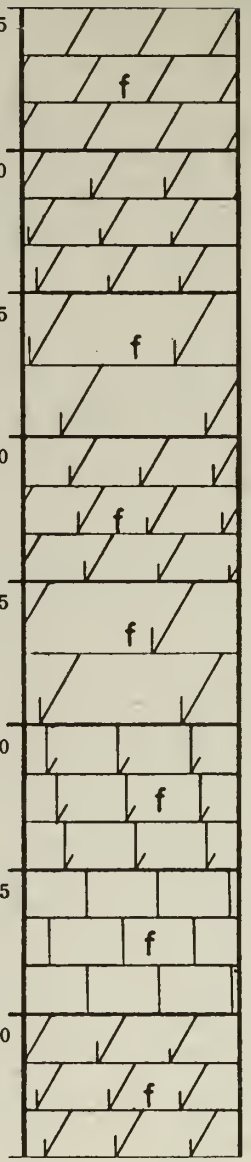
10	f	WhC Cp58: ls., brn.-pk., 90% fn. xln. calc. and crs. xln. sparry calc. in vugs and fracs., 10% fn. xln. dolo., pelletal-oolitic, mottled, brecciated, porous, argill., recryst., silica blebs, mang. grns. 1-2% limon. blebs and stn., weaths. brn-pk.
98	f-mic	WhC Cp57: dolo., light brn.-buff, 98% fn.-micro. xln. dolo., 2% sparry blebs of calc., lam.-alt. oolites and fn.-micro. xln., argill., joints and fracs with calc. cemen., spongy por., recryst., little silica as vug and pore lining, some Fe stain, weaths. gry.-buff, 2-12" beds.
90	f	WhC Cp56: dolo., gry.-yel. tan, 90% fn. xln. dolo., 10% fn. xln. intergran. calc. with some crs. sparry blebs calc. up to 1 cm., oolitic-pelletal?, fossil relics, x-beds, argill., recemen. fracs., recryst., slight Fe stain, mang., grns., weaths. buff-gry., massive beds.
90	f-mic	WhC Cp55: dolo., yel.-brn., 90% fn.-micro. xln. dolo., 10% fn. xln. intergran. calc. and med. sparry vug fill calc., oolitic, little fossil hash, argill., recemen. fracs., vuggy-spongy por., recryst., slight silica as vug lining, Fe stain pyrite?, mang., calc. strks, massive beds.
99	f-mic	WhC Cp54: dolo., light brn., 99% fn.-micro. xln. dolo., 1% med. xln. sparry calc. in fracs., slight lam., oolitic, some fossil hash, few small micro xln. dolo. blebs., argill., spongy-vuggy por., recryst., Fe stain, some mang., weaths. gry.-buff, massive beds.
95	f	WhC Cp53: dolo., light yel.-brn., 95% fn. xln. dolo., 2-3% med.-fn. xln. vug lining calc., pelletal-oolitic, dismicritic blebs, lam., x-lam., vuggy por., recryst., silica in blebs and nods. and also disem., 1-2% mang. grns., weaths. gry.-buff, massive beds.
75	f	WhC Cp52: dolo., brn.-pk., 75% fn. xln. dolo., 25% fn. xln. intergran. calc. and med. xln. sparry calc. patches, pelletal-oolitic, fossil molds, recryst., Fe stain, many mang. grns., weaths. gry.-brn., 2-3' beds.
60	f	WhC Cp51: calc. dolo., pk.-brn., 60% fn. xln. dolo., 40% med.-fn. xln. intergran. calc., calc. filled joints, Fe stain, mang. dend. and strks., hard, tough, 6-12" beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 6 of 14)



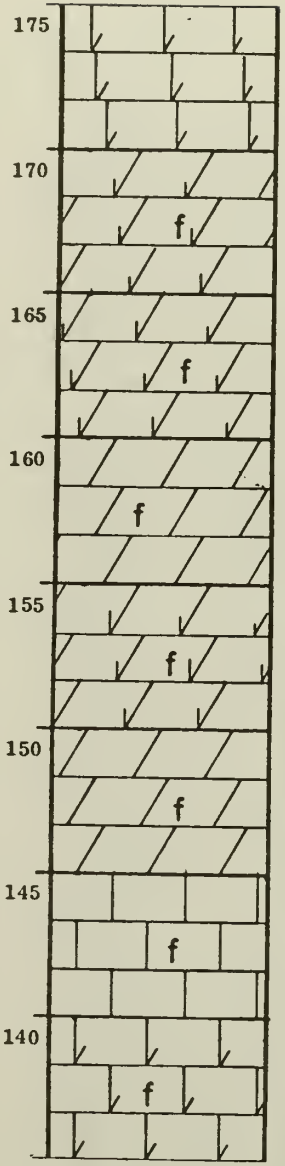
255	35	crs-f	WhC Cp50: dolo., ls., brn.-pk., 60% med.-crs. xln. sparry calc., 35% fn. xln. anhedral dolo., 3-4% mang. in dend. and grns., ringed with yel., pelletal-dismicritic, argill., joints with calc. fill, Fe stain, weaths. yel.-brn., 2-6" beds.
250	50	crs-f	WhC Cp49: calc. dolo., yel.-brn., 50% fn. xln. dolo., 50% fn. xln. intergran. and crs. xln. sparry calc., fossil molds, argill., vuggy por., 1% mang. grns., Fe stain, weaths. yel.-buff, 2-6" beds.
245	80	f	WhC Cp48: dolo., gry.-brn., 80% fn. xln. dolo., 20% fn. xln. sparry calc., lam. on weath., slight x-bed, dismicritic, fossil molds, vuggy por., 1-2% silica in blebs and lining pores, weaths. buff-gry., sdy feel, 2-3' beds.
240	80	m	WhC Cp47: dolo., gry.-yel.-tan, 80% med. xln. dolo., 20% intergran. and med. sparry calc., argill., joints, intergran. por., silica lining some pores, limon. spots-pyrite?, weaths. gry.-buff, sdy app., 2-12" beds.
235	95	m-f	WhC Cp46: dolo., yel.-brn., 95% med.-fn. xln. dolo., 5% crs. xln. sparry calc., pelletal?, argill., intergran. por., silica in blebs, Fe stain, jointed-frac., sdy feel, weaths. gry.-buff-yel., 2-12" beds.
230	75	m-f	WhC Cp45: calc. dolo., gry.-yel.-tan, 75% med.-fn. xln. rhombic dolo., 25% intergran. and frac. fill calc., pelletal., lam., x-lams., few purple spots and strks., recryst., silica in small blebs, Fe stain, mang. grns., weaths. gry.-brn.
225	80	f	WhC Cp44: dolo., gry.-buff, 80% fn. xln. dolo., 20% fn. xln.-med. xln. sparry calc., pelletal?, lam., x-lams., micro cut and fill, crinoids?, mud balls?, argill., intergran. por., weaths. buff-gry.
220	80	m-f	WhC Cp43: dolo., pk.-buff, 80% med.-fn. xln. dolo. with some good rhombs, 20% crs.-med. xln. intergran. and sparry calc. some 2-4 mm blebs, micrite blebs and smears, pelletal?, lam., x-lams., argill., 1+% dissem. mang., 12-18" beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 7 of 14)



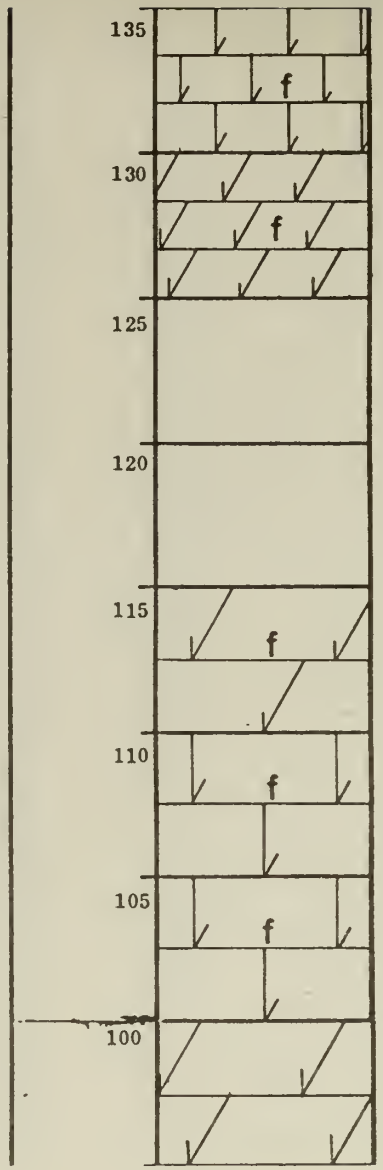
85	f	WhC Cp42: dolo., pk.-brn.-yel. mottled, 85% fn. xln. dolo., 15% med. xln. sparry and fn. xln. intergran. and crs. xln. fossil fill calc., lam., disrupted bedding (bioturbidite), fossil-brachs and crinoids poorly preserv., argill., recemen. fracs., silica blebs and few qtz. grns., limon., weaths. gry.-pk.-tan, 3-4" beds.
60	m-f	WhC Cp41: calc. dolo., pk.-brn., 60% fn. xln. dolo., 40% med. xln. sparry and intergran. calc., spines?, slight lams., blebs of silica, Fe stain., dense, hard, weaths. buff-yel.-brn.-pk., beds 1-8" variable.
50	m-f	WhC Cp40: calc. dolo., pk.-gry., 50% fn. xln. dolo., 50% fn. xln. intergran. and med. xln. sparry calc. some in fossil., slight. lam., some blebs of dolo. mic. to 5 mm, argill., limon., mang. dend., weaths. buff pk.-yel.-brn., 2-6' beds, steep cliff.
60	m-f	WhC Cp39: calc. dolo., pk., 60% fn. xln. dolo. with some poor rhombs, 40% fn. xln. intergran. and fn. xln. sparry calc., fossil-spines?, faint lams., argill., chert grns., chalced., mang. grns., vy hard, weaths. gry.-pk., dense.
75	m-f	WhC Cp38: calc. dolo., pk.-brn., 75% fn. xln. dolo., 25% med.-fn. xln. sparry calc., coral-brach-crinoids, pelletal?, argill., jointed, highly porous, punky, silica blebs, 1% mang. grns. with yel. leach ring, dense, 2-6' beds.
40	m-f	WhC Cp37: dolo. ls., gry.-brn., 60% fn. xln. sparry calc., 40% med.-fn. xln. dolo. some in patches, pelletal., fossil slight lam., blebs and stringers of micrite, mottled with dolo., argill. recryst., mang. dend., weaths. gry.-pk., 1-12" beds-varies laterally.
-	-	WhC Cp36: carb. fossil hash, light gry.-pk., 20-80% calc., fossil-crinoid and brach molds, banded, dismicritic-interclastic, lam., micrite blebs, pelletal?, argill., silica blebs, recryst., weaths. buff-pk.
50	m-f	WhC Cp35: calc. dolo., tan-pk., 50% med.-fn. xln. rhombic dolo., 50% med.-fn. xln. sparry calc. some in vugs, horn corals and fossil debris, lam.-mic.-fn. xln., blebby-splotchy-poss. recryst. pellets, argill., chert grns., Fe stain, mang. stn., 2-4" beds, weaths. buff pk.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 8 of 14)



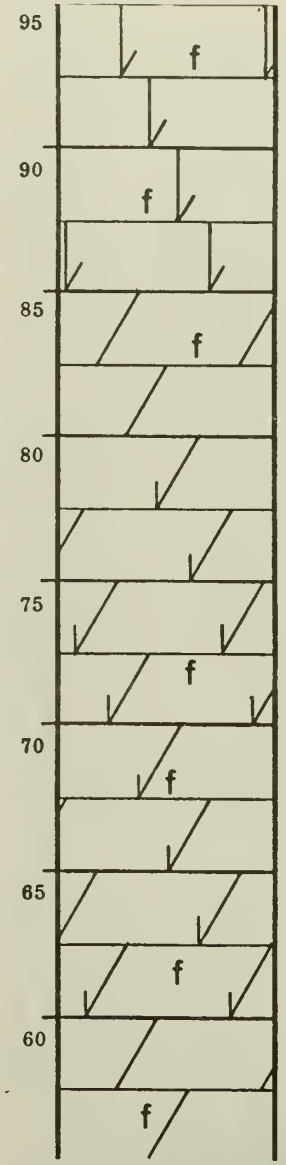
20	m-mic	WhC Cp34: dolo. ls., pk.-purple, 80% fn. xln. to med. xln. sparry calc. some in sparry blebs (molds?), 20% fn. xln. and micritic dolo., disruptive bedding-burrowed?, 2-3% qtz. grns., argill., jointed, zones of rhombs, varicolored, dense, hard, mang., 2-4" beds.
50	f	WhC Cp33: calc. dolo., gry.-brn., 50% fn. xln. partially rhombic dolo., 50% med. xln. sparry-intergran. calc., lam., fossil debris, micritic-dismicritic blebs, up to 2% chert or chalced., grns., arg., limon., few calc. lined vugs, hard, dense, 3-4" beds.
50	f	WhC Cp32: calc. dolo., gry.-brn., 50% fn. xln. rhombic dolo., 50% med. xln. sparry calc. with some patches of intergran. to 1/2 cm., pelletal?, lam., micritic-dismicritic blebs or interclasts, horn corals, brachs, crinoids, silica, argill., some Fe stain-pyrite?, calc. vugs, weaths. gry.-tan, 3-4" beds.
95	f	WhC Cp31: dolo., gry.-brn., 95% fn. xln. dolo., 5% intergran. and med. xln. sparry calc., mud lumps, blebs of sparry calc. to 1 cm., some chert stringers, fossil molds and debris, slight lam., argill., Fe stain in fracs and blebs (pyrite?), mang., dense, tough, jointed, 3-4" beds.
50	f	WhC Cp30: calc. dolo., gry., 50% fn. xln. dolo., 50% intergran.-sparry fn. xln. calc., recryst. pelletal?, fossil debris and molds-crinoid-brach some lined with calc., blebs of sparry calc. to 3 mm., chert or chalced. grns., argill., Fe stain (pyrite?) liesegang ring, jointed, 4-6" beds.
50	f	WhC Cp29: dolo., brn., 95% vfn. xln. dolo. with some big rhombs, 3% med. xln. sparry calc., 2% fn. grn. qtz. and chert or chalced. part. lam., lg. dismic. blebs, brachs and crinoid hash, jointed, partly recryst., Fe stain conc. in fracs., weaths. gry.-brn., 6-8" beds, brn. chert.
15	m-mic	WhC Cp28: ls., brn., 85% sparry and micritic med.-micro xln. calc., 15% fn. xln. rhombic colo., pellets and blebs of clay and micrite, crinoids and brachs, chert nods., blebs of silica, recryst., recemen. horsetail fracs., slight Fe stain, weaths. gry.-brn. with pk. strks., 4-18" beds.
45	f-mic	WhC Cp27: dolo. ls., light brn., 55% micritic calc. in.blebs and oolites?, 45% fn. xln. rhombic dolo., lam., blebs or interclasts, few vfn. qtz. grns., fossil relics, jointed, slight Fe stain, mang. stringers, weaths. gry.-wh., 2-8" beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 9 of 14)



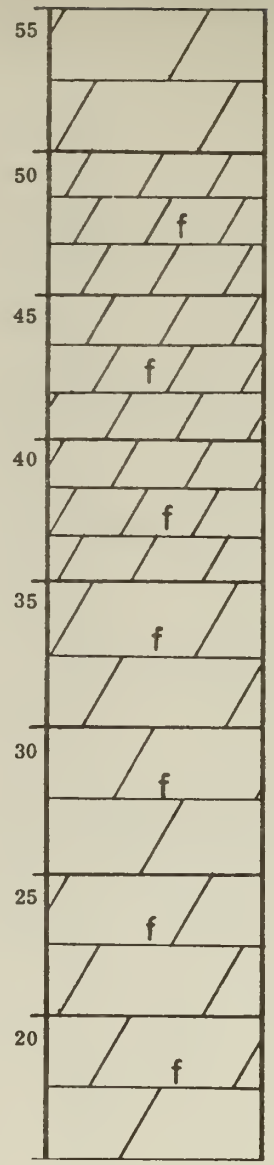
25	f-mic	WhC Cp26: dolo. ls., gry.-buff, 75% micritic calc., 25% fn. xln. rhombic dolo., pelletal-interclastic, interclasts or blebs of micrite, weaths. lam., x-lam., recryst. oolites, fossil relicts, argill., jointed, slight Fe stain, slight mang., dense, tough, rings when struck, weaths. gry.-wh., 8-1/2" beds, cliff face.
70	m-f	WhC Cp25: calc. dolo., gry.,-buff, 70% fn. xln. dolo., 30% med. xln. sparry blebs and intergran. calc. some in fossil crinoids, pelletal, fossil relicts brach and crinoids, micritic blebs or streaks, occ. chert, argill., vuggy and intergran. por., recryst., some hematite, 6-12" beds.
		Covered.
80	m-mic	WhC Cp24: calc. dolo., yel.-buff-pk. mottled, 80% med.-fn. xln. dolo. and micro xln. blebs, pelletal?, fossil hash, micrite blebs and interclasts, lam., algal stringers?, x-bed on weath., argill., vuggy por., recryst., hematite-migrating to weath. rind, mang., weaths. gry.-buff, massive beds.
50	f	WhC Cp23: dolo. ls., yel.-tan, 50% calc. in oolites and intergran., 50% fn. xln. intergran. dolo., oolitic, brachs, jointed, vuggy por., recryst., hematite migration near weath. rind, calc. invugs and ptgs., weaths. gry.-buff, massive beds, cliff former, rings like a bell.
50	m-f	WhC Cp22: dolo. ls., yel.-tan, 50% calc. in oolites and intergran., 50% fn.-med. xln. dolo. intergran., pelletal-oolitic, crinoid and brachs, argill., recryst., limon., occ. chert, rings, massive.
75	f	WhC Cp21: calc. dolo., buff-tan, 75% fn. xln. dolo., 25% fn. xln. calc. intergran.-in oolites and some in fracs. and vugs, oolitic, some crinoidal material, spongy por., recryst., occ. chert, vy hard, massive beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 10 of 14)



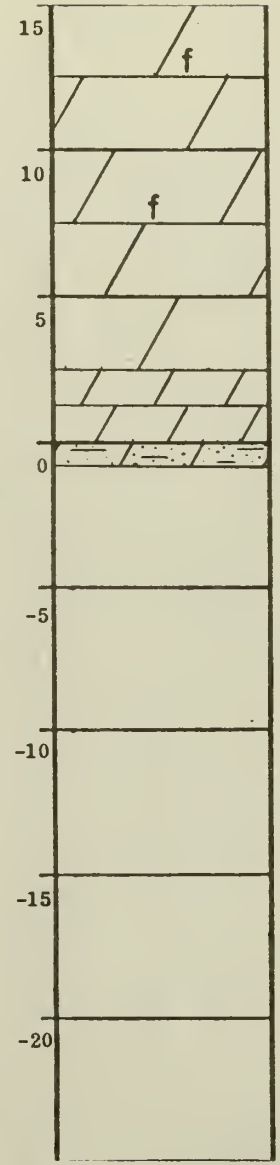
20	f-mic	WhC Cp20: dolo. ls., gry.-buff-tan, 80% calc., 20% dolo. in rhombs and spar., oolitic, crinoid trash - some spines and brachs, chert nods., slight argill., Fe stain, frac.-stellate, jointed and broken, man.-migrating to or from weathered surface, strks. of ls. and dolo., massive beds unless sheared and jointed, rings like a porcelain on talus slope.
40	f	WhC Cp19: dolo. ls., gry.-buff-tan, 60% calc. in oolites and blebs., 40% fn. xln. intergran. dolo., oolitic, few micritic blebs, fossil trash and few recryst. brachs, argill., recryst., Fe stain, sheared, jointed, chert, rings when struck, massive.
90	f	WhC Cp18: dolo., gry.-buff, 90% fn. xln. dolo., 10% intergran. calc. cement with a few sparry patches, pelletal?, few crinoids and brachs, slight argill., recryst., slight Fe stain, jointed, strks. of calc., massive.
50	f	WhC Cp17: calc. dolo., gry.-buff, 50% fn. xln. dolo., 50% intergran. calc. cement with some as vug fill and blebs, argill. vuggy-intergran. por., recryst., some mang., massive beds.
50	f	WhC Cp16: calc. dolo., gry.-buff, 60% fn. xln. dolo., 40% intergran. calc. cement with some patches, dismicritic and pelletal?, some brachs, argill., recryst., weaths. gry.-buff, massive beds.
65	f	WhC Cp15: calc. dolo., gry.-buff, 65% fn. xln. rhombic dolo., 35% calc. intergran. cement and as fill in recent fracs. and in crinoids and blebs, pelletal., fossil relicts, slight argill., recryst., slight Fe stain, weaths. gry., massive beds.
50	m-f	WhC Cp14: calc. dolo., gry.-buff, 50% med.-fn. xln. dolo., 50% intergran. calc. cement and calc. in blebs, lam., crinoid frags., argill., recryst., some Fe stain, weaths. gry., massive beds.
95	f	WhC Cp13: dolo., light buff-brn., 95% fn. xln. rhombic dolo., 5% calc. intergran. and as vug fill and blebs, lam. and x-lam., argill., some crinoid molds, vuggy and intergran. por., recryst., fresh chip is less vuggy, some mang., frac. and jointed, brittle, weaths. gry.-buff, massive beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 11 of 14)



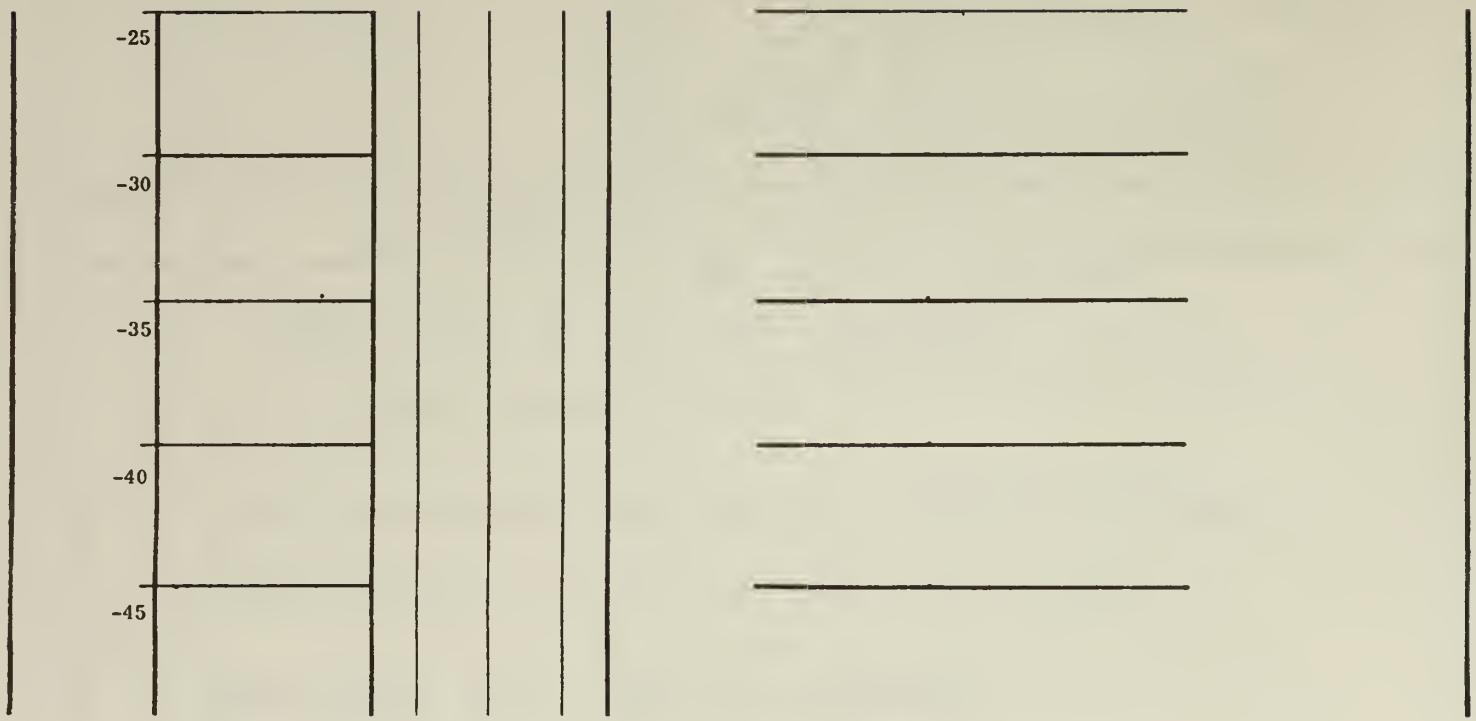
95	f	WhC Cp12: dolo., light brn. with pk. strks., 95% fn. xln. dolo., 5% calc. cement and frac. fill, weaths. x-lam., argill., vuggy and intergran. por., limon. stain, hematitic rich stylolite zone 3-4 mm wide, recryst., weaths. buff-gry., massive beds.
95	f.	WhC Cp11: dolo., brn., 95% dn. xln. rhombic dolo., 5% calc. in vugs and fracs., pelletal?, some silica in pore linings, some crinoid molds and small brachs, brn. nodular chert in ovoid globs, vuggy por., recryst.
90	f	WhC Cp10: dolo., yel.-tan to buff, 90% fn. xln. sacc. dolo., 10% calc. as sparry cement and in crinoids-blebs and vugs, lam., fossil relics, pelletal?, argill., recryst., some pyrolu., grns., slight Fe stain, weaths. gry.-buff.
98	f	WhC Cp9: dolo., brn.-pk. mottled, 98% fn. xln. dolo., 1-2% calc. in blebs-crinoids-frac. fill, lams. on weath., fossil relics, some spongy por., recryst., Fe stain, some mang., weaths. gry.-brn., massive beds.
98	f	WhC Cp8: dolo., light brn., 98% fn. xln. dolo., 2% calc. in crinoid molds, weath. to lams., argill., recryst., limon., sugary, massive beds.
99	f	WhC Cp7: dolo., brn., 99% fn. xln. dolo., small amt. of calc. in crinoid molds, blebs or interclasts of vfn xln. dolo., mottled, argill., some spongy por. few vugs, recryst., limon., weaths. gry-brn., massive beds, does not look fresh.
90	f	WhC Cp6: dolo., brn., 90% fn. xln. dolo., 10% calc. in crinoids and fracs, fossil relics, argill., recryst., limon., porous, few vugs, sugary, massive beds.
85	f	WhC Cp5: dolo. brn., 85% fn. xln. dolo., 15% calc. cement in fracs. and crinoids, fossil relics, soln. breccia locally, contorted structures, argill., recryst., fracs. some brecciated and recemen., limon., weaths. gry., massive beds.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 12 of 14)



95	f	WhC Cp4: dolo., brn., 95% fn. xln. dolo., 2-3% calc. in blebs-stringers and crinoid molds, much crinoidal material, argill., 1-2% limon. with clay, mang., massive 12-15' beds, weaths. gry.
85	f	Whc Cp3: dolo., brn.-yel., 85% fn. xln. dolo. (bimodal xln.), 15% sparry calc. in crinoids and fracs., ripple marks on bedding surface, recryst. crinoids, argill., little silica lining crinoids, fairly high Fe content, recryst., Fe stain, pyrolusite, weaths. brn., 12-18" beds, cliff.
95	vf	WhC Cp2: dolo., yel.-brn., mottled, 95% vfn. xln. dolo., minor calc. in frac. fill, 3-4% fn. grn. qtz. sand, silica in blebs, hematite nodules and in fracs. and disseminated, faint x-lams., argill., limon. stain, weaths. brn., 6-18" beds, large cliff.
-	-	WhC Cel: silty argillaceous dolo., interbedded dolo. shale, purple-pk.-gry., hematite nodules, geodes, jointed, x-beds, transition to Cp, THE ENGLEWOOD Fm.

WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 13 of 14)



WHITEWOOD CREEK SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 14 of 14)

Surface Section - Pahasapa Limestone

SPEARFISH CANYON

Lawrence Co., South Dakota

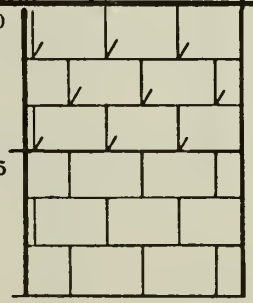
Top of section in SW1/4,SW1/4,NE1/4,Sec.33,T6N,R2E

Bottom of section in NW1/4,NE1/4,SE1/4,Sec.33,T6N,R2E

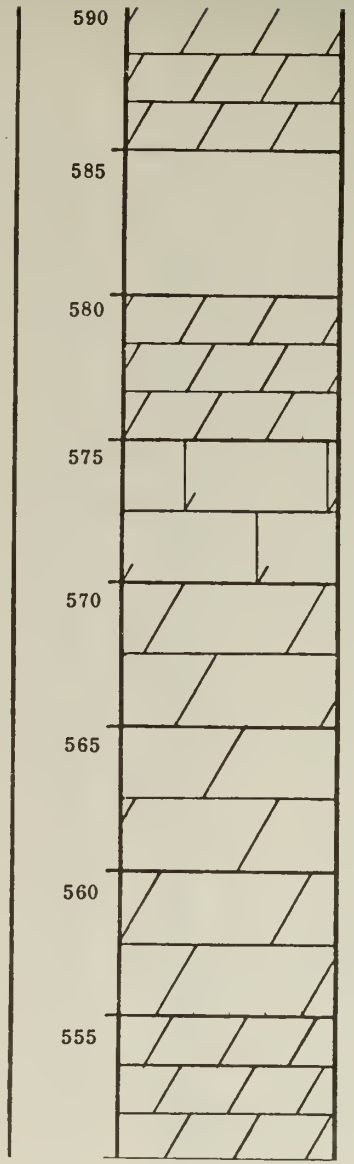
Vertical scale: 1" = 5'

Dept. of Geol. & Geol. Eng., S.D.S.M.&T., 7/71

By J.C.M., J.P.G., D.C.B., P.D.C.

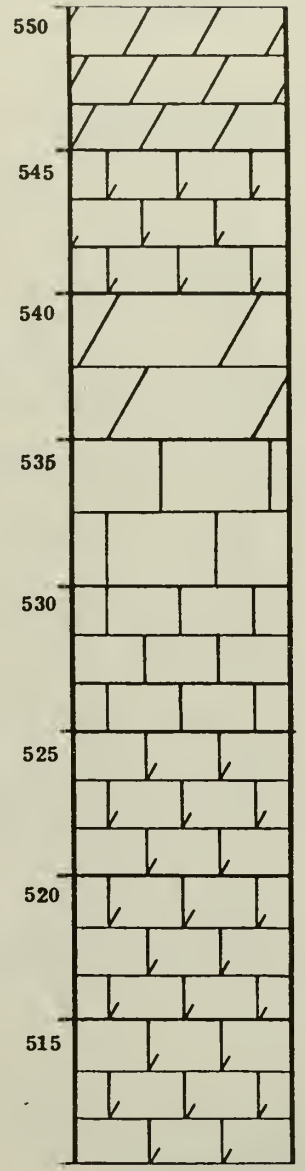
		% Dolo.	Grain Size	
600		30	mi-f	SpC Cp1: ls., dolomitic, gry. brn., weaths. gry. 50% fn. xln. calc., 30% fn. xln. dolo. 15% mic. mtx., 5% fn. calc. cmt. Few 1/2 mm fractures filled with calc. Trace hematite. Very dense sub-lith. Thin bedded.
595		0	mi	SpC Cp2: ls., gry. 100% mic. calc. slightly fossil. Few 1/10 mm fractures filled with calc. Lithographic.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 1 of 16)



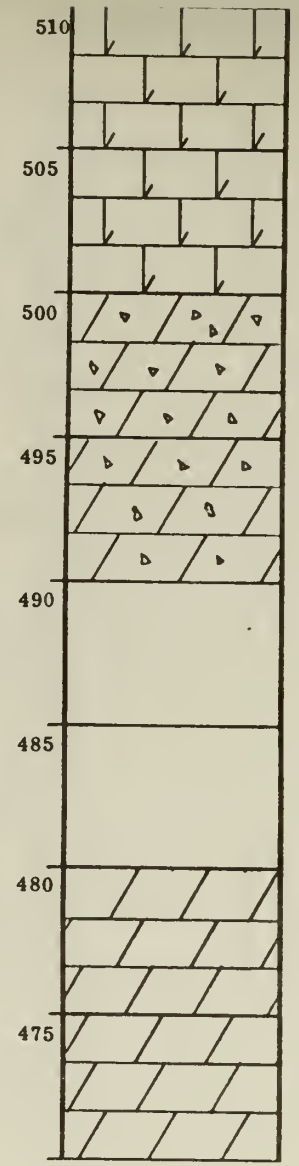
55	f	SpC Cp3: dolo., calc. gry. brn. weaths. gry. 45% fn. xln. 35% fn. xln. calc. 10% dolo.-10% calc., microxln. mtx. 1-2 mm discont chert stringers. Ghost pellets.
		Covered. Gry. in float.
70	f	SpC Cp4: dolo. cream-white, weathers gry. 70% fn. xln. dolo. 30% calc. in fractures. Some small 3-4 mm blebs of calc. Few chert stringers. Fe streaks. Very dense. Mostly covered.
30	f	SpC Cp5: ls., dolomitic. Gry. tan, weaths. gry. tan. 70% fn. xln. calc., 30% fn. xln. calc. Calc. re-cemented fractures. Chert nodules. Beds 6"-18", partly covered.
90	f	SpC Cp6: dolo., mottled cream-gry.-brn. weaths. dk. brn. 90% fn. xln. dolo., 10% fn. xln. calc. Clay streaks, chert gns. and nodules. Limonite stain, fine fractures. Beds 8"-12", poorly exposed.
50	f	SpC Cp7: dolo. gry. tan, weaths, very dk. gry. 50% fn. xln. dolo. 50% fn. xln. calc. Little silica. Fractures filled with sparry calc. Beds 12", poorly exposed.
80	f	SpC Cp8: dolo. gry.-yel. mottled, weaths. dk. gry. 80% fn. xln. dolo., 20% fn. xln. calc. Few 1 mm. Patches of sparry dolo. Argill. blebs and stringers. Bed 4' thick.
90	f	SpC Cp9: dol., cream-white, weaths. gry.-buff. 90% fn. xln. dolo., 10% fn. xln. calc. Few 1/10 mm limonite stains (pyrite?), porous. Beds ave. 6".

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 2 of 16)



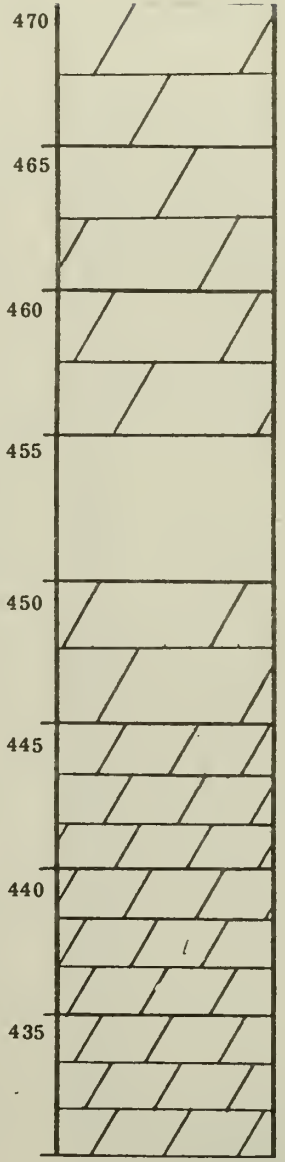
80	f	SpC Cp10: dolo. gry.-yel.-brn., weaths. gry. brn. 80% fn. xln. dolo., 15% fn. xln. calc. 3-5% chert gns. Calc. streaks and stringers. Pyrite. Some fossil relics. Beds 4"-6".
15	f	SpC Cp11: ls., dolomitic, mottled gry.-pk.-buff. Weaths. gry. brn. 55% fn. xln. calc., 15% fn. xln. dolo. 30-35% fn. xln. calc. cemt. Pelletal. Fossil hash - relic Syringopora. Fn. calc. filled fractures. Beds 8".
75	f	SpC Cp12: dolo., calc., mottled gry.-brn. weaths. gry. brn. 75% fn. xln. dolo., 25% fn. xln. calc. Sparry fossil frags. Slightly laminated, argillaceous. Hackly fracture. Beds 24".
40	f	SpC Cp13: ls., gry., weaths. gry. buff. 30% med. xln. calc., 40% med. xln. dolo., 30% fn. xln. calc. cemt. pelletal., dismic. crinoids, brachs, coral. Pyrite-limonite. Jointed, sheared. Massive bed.
40	f	SpC Cp14: ls., gry. buff, weaths. dk. gry. 40% fn. xln. calc., 35% fn. xln. dolo., 20% fn. xln. calc. cemt., 5% fn. xln. dolo. Pelletal., dismic. Slight chert. Brach, etc. hash. Limonite stained.
40	f	SpC Cp15: ls., dolomitic, buff, weaths. pnk. to red. 40% fn. xln. calc., 35% fn. xln. dolo., 20% fn. xln. calc. cemt., 5% fn. xln. dolo. cemt. Pelletal., dismic. Crinoids, brachs.
35	f	SpC Cp16: ls., dolomitic, buff, weaths pnk. to red. 40% fn. xln. calc., 35% fn. xln. dolo., 25% calc. cemt. Brach hash and valves Syringopora. Fractured.
35	f	SpC Cp17: ls., dolo. yel.-brn.-gry. weaths. buff. 40% fn. xln. calc., 30% fn. xln. dolo., 25% med. calc., cemt., 5% med. dolo. cemt. Pelletal., dismic., argill. in part. Crinoids, brachs, forams, algal strings. Sheared. Beds 6"-3'.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 3 of 16)



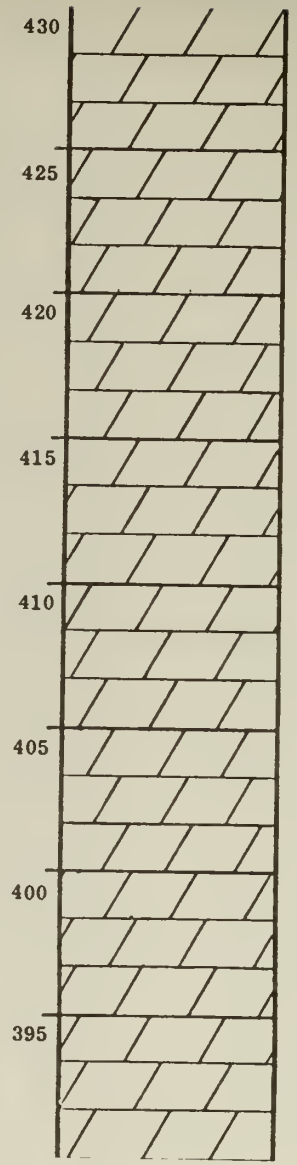
30	f	SpC Cp18: ls., dolo. tan-gry., weaths. buff dk. gry. 40% fn. xln. calc., 30% fn. xln. dolo., 30% med. calc. cemt. Pelletal., dismic. Whole brachs, crinoids, etc. Sheared, vert. cliff. Beds 3'.
35	f	SpC Cp19: ls., dolo. gry. weaths. buff. 40% fn. xln. calc., 30% fn. xln. dolo., 15% mic. mtx., 10% calc. cemt., 5% fn. xln. dolo. cemt. Crinoids, brachs, algal stringers, etc. Recryst. Calc. filled. Fractures. Beds 12"-36".
-	-	SpC Cp20: ls., dolomite breccia. Yel.-brn. weaths. buff-tan. Mostly dolomite calsts. Chert, argillaceous. Limonite blebs, gypsum infilling. Some spar patches to 10 mm. Large sol. cavities. Bedding lost to brec.
-	-	SpC Cp21: ls., dolomite breccia. gry., weaths. red brn. Clasts of microxln. dolo. 40-50% sparry calc. cement. Fe stain and blebs. Some brachs. Cavernous.
-	-	Covered.
-	-	Covered.
100	f	SpC Cp22: dolo., brn. weaths. gry. brn. 100% fn. xln. dolo. slightly lamin. Molds and hash. Small limo. stns. and gns. Fractured and shattered.
100	f	SpC Cp23: dolo., lt. brn., weaths. gry. brn. mottled. 100% fn. xln. dolo. sacc. Limonite stains and blebs - pyrite.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 4 of 16)



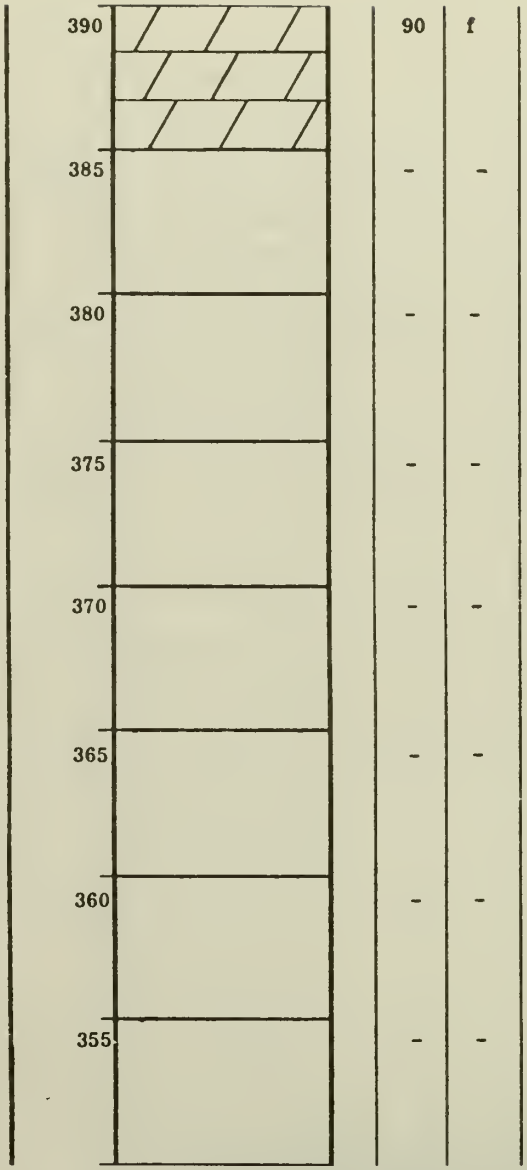
470	100	vf	SpC Cp24: dolo. gry. brn., weaths. gry. 100% fn.-vfn. dolo. patches of fn. xln. dolo. spar. Vuggy porosity. Fe stain. Recryst. Fractures. Beds massive.
465	100	f	SpC Cp25: dolo., gry., weaths. red-stained gry. 100% fn. xln. sacc. dolo. Some vuggy porosity, some Fe stain. Recryst. Beds massive.
460	100	f	SpC Cp26: dolo. lt. brn., weaths. gry. buff. 100% fn. xln. sacc. dolo. Slightly argill. Stringers of chert. Molds-xl. lined. Vuggy porosity. Recryst. Fe-stained. Beds massive.
455	90	f	SpC Cp27: dolo., buff yel., weaths. dk. gry. 90% fn. xln. dolo., 10% fn. xln. calc. Sacc. Slightly argill. Spongy. Few fossil relics. Recryst.
450	100	f-m	SpC Cp28: dolo., brn., weaths. dk. gry. 100% fn.-med. sacc. dolo. Slightly argill.-calc. Vuggy-spongy. Recryst. Vert. cliff. Beds very massive.
445	100	mi-f	SpC Cp29: dolo. brn., weaths. brn. gry. 100% mic.-fn. xln. dolo. Slightly argill. Pelletal. Vuggy porosity. Recryst. Vert. fractures. Beds very massive.
440	100	f	SpC Cp30: dolo., brn., weaths. gry. brn. 100% fn. xln. dolo. Sacc. Slightly argill. Slightly shattered. Bedding very massive-indistinct.
435	100	f	SpC Cp31: dolo. brn., weaths. gry. brn. 100% fn. xln. sacc. dolo. Pelletal. Few fossil molds. Recryst. Vuggy porosity. Beds massive - indistinct.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 5 of 16)



430	95	f	SpC Cp32: dolo. brn. weaths. brn. gry. Red stn. 95% fn. xln. dolo. Sacc. 5% fn. calc. cemt. Slightly argill. Fe-stained. Recryst. Fract. red. Cliff. Beds very massive.
425	100	f-m	SpC Cp33: dolo. wh. weaths. yel. brn. 100% fn.-med. dolo. Sacc. in part. Pelletal. Vuggy porosity - some chert lined. Slight Fe stain. Recryst. Vert. fracturing. Shearing. Cliff.
420	95	f	SpC Cp34: dolo. brn. weaths. brn. 95% fn. xln. sacc. dolo., 5% fn. xln. calc. Slightly argill. Vuggy porosity. Slight Fe stain. Recryst.
415	100	f	SpC Cp35: dolo. brn. weaths. brn. 100% fn. xln. sacc. dolo. Pelletal. Fe stain. Vuggy porosity - some silica lined, spongy. Recryst.
410	100	f	SpC Cp36: dolo. brn. weaths. brn. 100% fn. xln. sacc. dolo. Pelletal. Slightly argill. Fossil molds - vuggy porosity. Slight Fe stain. Recryst.
405	100	f	SpC Cp37: dolo. brn. 100% fn. xln. sacc. dolo. Pelletal. Fossil molds. Vuggy porosity. Slight Fe stain. Recryst. Fractured - shattered.
400	75	f	SpC Cp38: dolo. brn. 75% fn. xln. sacc. dolo., 25% fn. xln. calc. Some calc. in stinger and fractures. Pelletal. Fossil molds - vuggy porosity. Slightly argill. Slight Fe stain. Some chert. Recryst.
395	95	f	SpC Cp39: dolo., lt. yel. brn. weaths. yel. 95% fn. xln. sacc. dolo., 5% fn. xln. calc. Bands of chert nodules. Fe-stained. Mang, gns. Vuggy porosity. Base of Cliff.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 6 of 16)

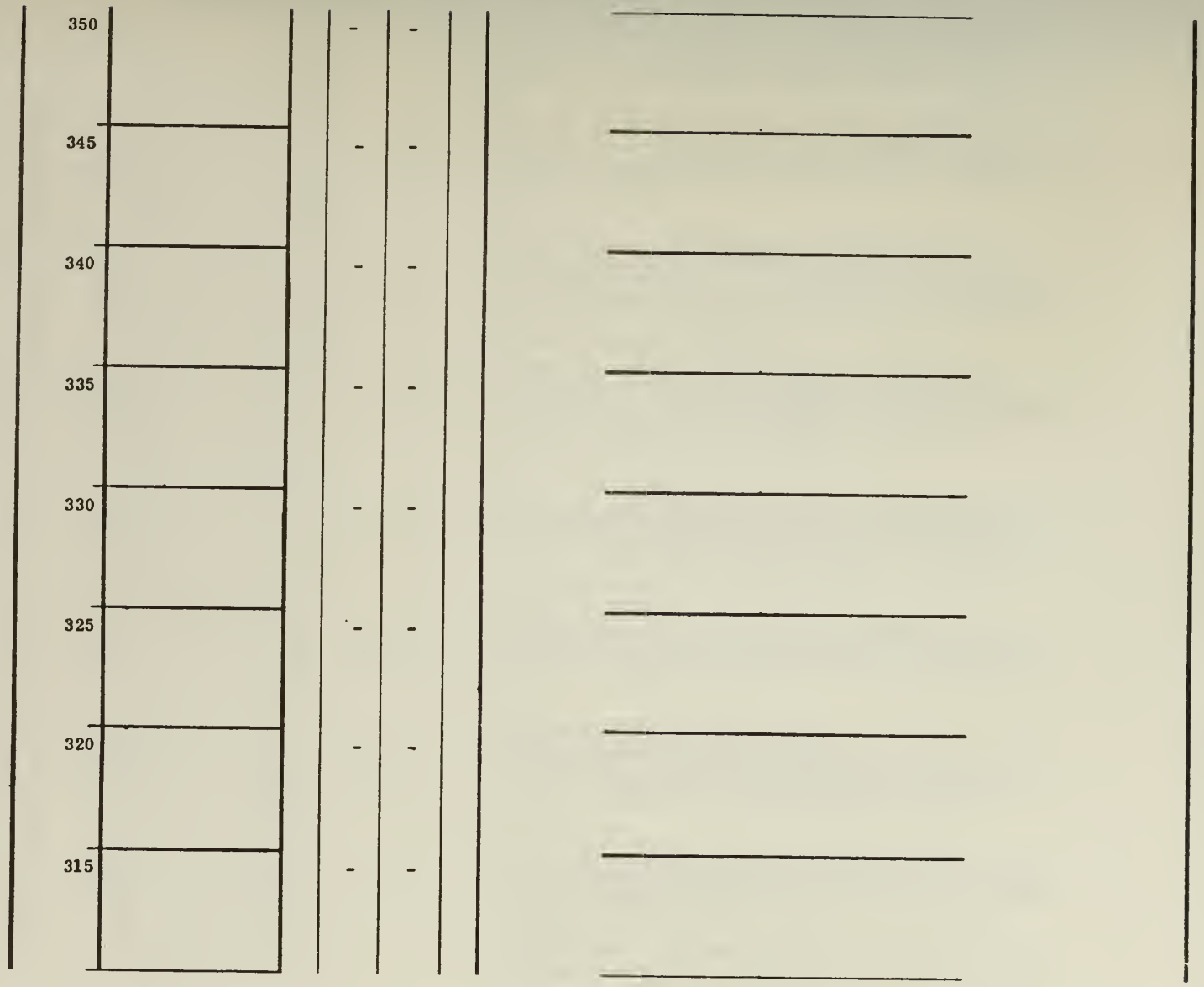


390	90	f
385	-	-
380	-	-
375	-	-
370	-	-
365	-	-
360	-	-
355	-	-

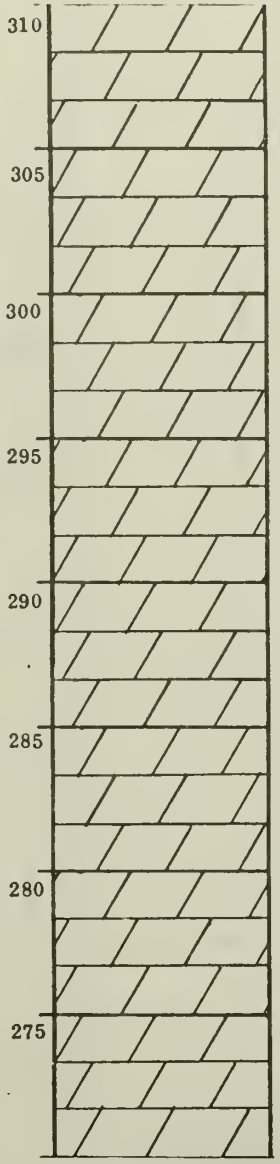
SpC Cp40: dolo. cream yel. weaths. dk. gry. to yel. 90% fn. xln. sacc. dolo., 10% calc. in 2-3 mm euhedral masses. Fossil molds. Slight Fe stain. Vuggy porosity. Recryst. Shattered. Beds 3-4'.

Covered. Rubble in grass covered slope. Base of cliff.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 7 of 16)

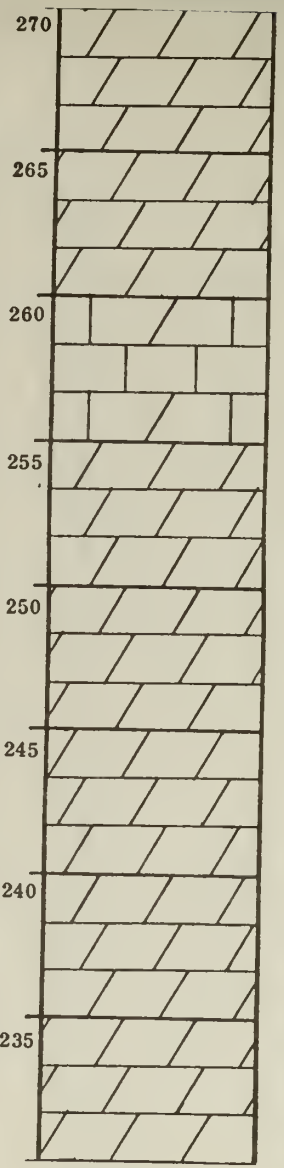


SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 8 of 16)



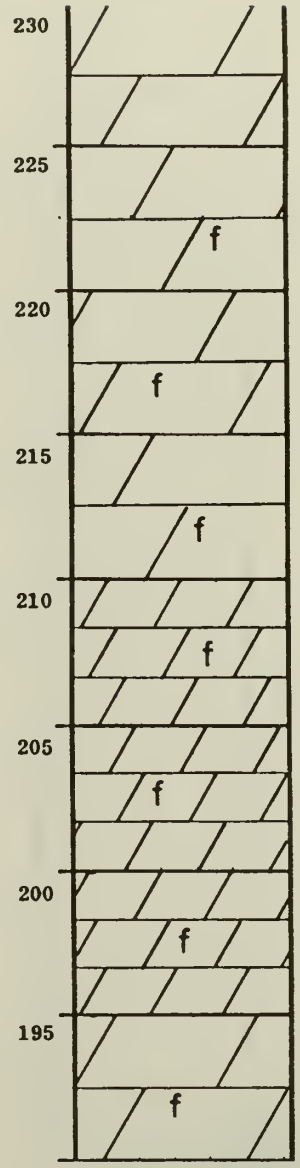
310	100	f -	SpC Cp 41: dolo. gry. wh. weaths. gry. buff. 100% fn. xln. dolo., few scattered patches of calc. Pelletal. Slightly lam. Frags. echinos., coral, brachs, and some algal blebs. "Reefoid". Slight Fe stain. Recryst. Beds 8-12".
305	60	f	SpC Cp42: dolo., calc. gry. wh. weaths. gry. buff. 60% fn. xln. dolo., 40% fn. xln. calc. Pelletal. Slightly argill. Fe. stain. Some Mn. gns. Slight chert. Recryst.
300	100	f	SpC Cp43: dolo. tan - lt. brn. weaths. buff gry. 100% fn. xln. sacc. dolo. Pelletal. Slightly argill. "Algal" fossil molds-vuggy porosity. Some chert.
295	100	f	SpC Cp44: dolo. lt. brn. weaths. brn. gry. 100% fn. xln. sacc. dolo. Pelletal. Zones of vuggy-spongy porosity. Recryst. Beds 8"-3'.
290	50	f	SpC Cp45: dolo. gry. tan, weaths. dk. gry. 50% fn. xln. dolo. 50% calc. vug fill. Pelletal. Few fossil frags. x-lam. Some chert in vugs. Recryst.
285	95	f	SpC Cp46: dolo. pnk. weaths. gry. tan. 95% fn. xln. dolo. 5% blebs calc. Pelletal. Laminated. Slightly argill. Vuggy porosity. Recryst. Steep cliff. Beds 12-24".
280	95	f	SpC Cp47: dolo. pnk. tan, weaths. gry. tan. 95% fn. xln. sacc. rhomb. dolo., 5% fn. xln. calc. Slightly argill. Slight Fe stain. Some slight vuggy zones. Recryst.
275	60	f-m	SpC Cp48: dolo., gry. pnk., weaths. yel. gry. 60% med.-fn. xln. dolo., 40% med.-fn. xln. calc. cemt. Pelletal. X-lam. Slight Fe stain - pyrite. Recryst. Beds 12".

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 9 of 16)



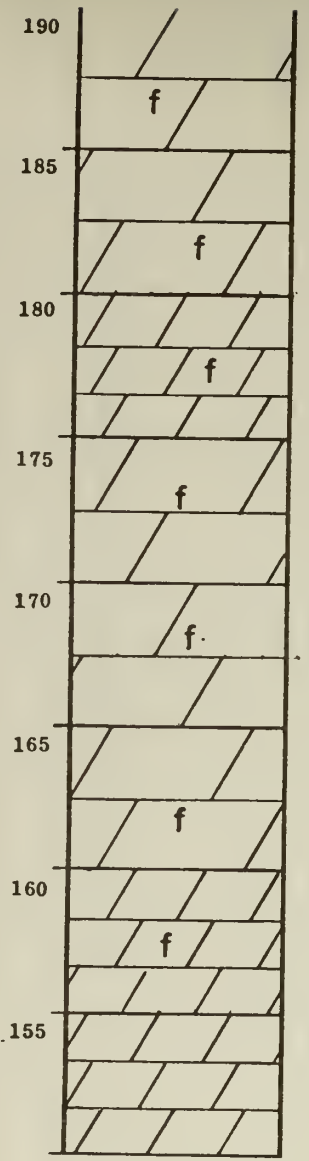
270	50	m-f	SpC Cp49: dolo., calc. gry. tan, weaths. brn. gry. 50% med.-fn. xln. rhomb. dolo., 50% med.-fn. xln. calc. Pelletal. X-lam. Slight Fe stain. Recryst.
265	75	f-m	SpC Cp50: dolo. gry. tan. 75% fn.-med. xln. rhomb. dolo., 25% med. xln. calc. cemt. Slight Fe stain. Porous. Recryst. Beds 2-6".
260	50	f	SpC Cp51: ls., dolo., gry. tan, weaths. brn., gry. 50% fn. xln. calc. with blebs and stringers of med. xln. calc. 50% fn. xln. dolo. Argill. Fe stain - pyrite. Sheared, vert. Fractures. Platy beds.
255	60	f	SpC Cp52: dolo., lt. brn., weaths. buff tan. 60% fn. xln. dolo., 40% fn. xln. calc. Some qtz. silt. Recryst. Sheared, fractured. Beds 12-36".
250	90	f	SpC Cp53: dolo., brn., weaths. brn. 90% fn. xln. sacc. dolo., 10% fn. xln. calc. cemt. Pelletal. Few stringers of clay. Slight Fe stain. Some vuggy-spongy porosity. Sheared, fractured. Bedding indistinct.
245	70	f	SpC Cp54: dolo., brn., weaths. brn., 70% fn. xln. sacc. dolo., 30% med. xln. calc. cemt. Slightly laminated. Slight Fe stain. Sheared, fractured. Bedding indistinct.
240	75	f	SpC Cp55: dolo., pnk. mottled tan, 75% fn. xln. dolo., 25% med. xln. calc. Pelletal. Laminated. Slightly argill. Spotty Fe stain. Vuggy porosity. Recryst. Beds 8-12".
235	70	f	SpC Cp56: dolo., gry. pnk., weaths. gry. brn. 70% fn. xln. dolo., 39% med. xln. calc.-blebs to 3 mm. Slightly laminated. Mic. blebs and stringers. Slight Fe stain. Fractured and recemented. Recryst. Beds 6-12".

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 10 of 16)



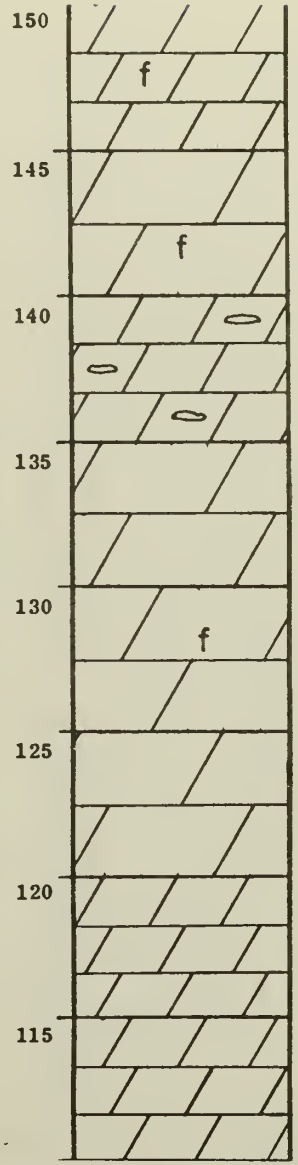
70	f	SpC Cp57: dolo., gry. brn. 70% fn.-mic. dolo., 30% med. xln. calc. Slightly lam. Mottled blebs of dolomicrite. Floating angular gns. qtz. Slight Fe stain. Recemt. fractures. Recryst. Beds 12".
70	f	SpC Cp58: dolo., gry. brn., weaths. buff. 70% fn. xln. rhomb; dolo., 30% med. xln. calc. cemt. X-lam. Slightly argill. Interclastic-crinoid hash. Slight Fe stain. Recemt. fractures. Recryst. Beds 24".
50	f	SpC Cp59: dolo., calc., lt. brn., weaths. gry. brn. 50% fn. xln. rhomb. dolo., 50% med., xln. calc. Laminated. Brachs. Slight Fe stain. Beds 18-24".
55	f	SpC Cp60: dolo., tan-pnk. 55% fn. xln. rhomb. dolo., 45% med. xln. calc. (some mangano-calcite). Crinoids. Recryst. Recemented fractures. Beds 12-18".
75	m-f	SpC Cp61: dolo., tan pnk., weaths. yel.-brn.-gry. 75% med.-fn. xln. rhomb. dolo., 25% med. xln. calc. Pelletal. Few crinoids. Slightly argill. Slight Fe stain. Slight vuggy porosity. Recryst. Fractured. Beds 6-12".
60	m-f	SpC Cp62: dolo., lt. gry. tan, weaths. gry. buff. 60% med.-fn. xln. rhomb. dolo., 40% med. xln. calc. some patches 2-3 mm. Argill. X-lam. Some crinoid frags. Vuggy-spongy porosity. Some Fe stain. Recryst.
95	f	SpC Cp63: dolo., and ls. alternating. Pnk and tan. 95% fn. xln. rhomb. dolo., 5% fn. calc. Some fn. ang. qtz. gns. Crinoids, brachs, coral. Laminated, Vuggy porosity - "Reefoid". Clay and pyrite. Beds 3".
95	f-m	SpC Cp64: dolo., brn., weaths. gry. 95% fn.-med. xln. rhomb. dolo., 5% med. xln. calc. Laminated. Fossil molds-vuggy porosity. Fe stain. Recryst. Beds massive.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 11 of 16)



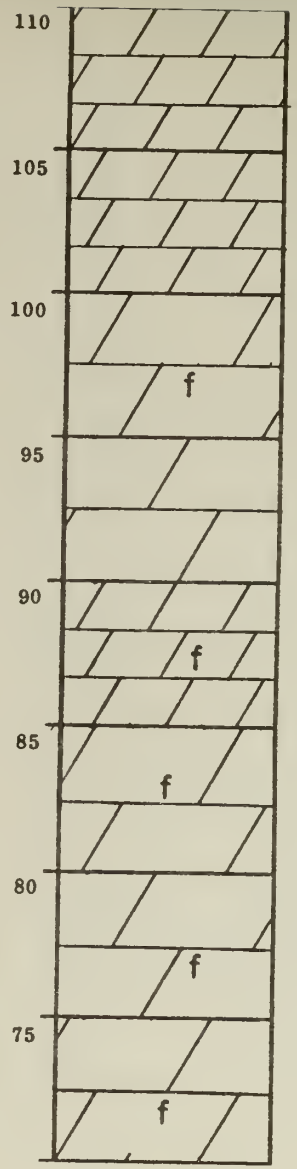
90	f	SpC Cp65: dolo., brn., weaths. gry. brn. 90% fn. xln. rhomb. dolo., 5% med. xln. calc. Slightly laminated. Fossil molds-crinoids. Vuggy porosity. Slight Fe stain. Recryst. Beds massive.
100	vf	SpC Cp66: dolo., brn., weaths. gry. 100% very fn. xln. dolo. Argill. lams. Few qtz. gns. Few fossil molds. Zones of vuggy por. Fe stain-pyrite. Recryst. Beds massive.
100	f	SpC Cp67: dolo., yel. 100% fn. xln. dolo. Banded - sacc. in part. Mic. interclasts. Argill. Fossil molds. Vuggy porosity in zones. Recryst. "Reefoid"
75	f	SpC Cp68: dolo., gry. tan. 75% fn. xln. dolo. 25% med. xln. calc. cemt. Laminated. Argill. "Reefoid". Fossil molds-vuggy porosity. Mic. interclasts. Alt. pyrite cubes. Recryst. Beds 12-36".
100	f	SpC Cp69: dolo., tan yel., weaths. yel. gry. 100% fn.-very fn. xln. dolo. Laminated. Few qtz. gns. Argill. Few fossil molds. Vuggy porosity. Fe stain.-pyrite. Beds 6-18".
90	f	SpC Cp70: dolo., brn. mottled pnk., weaths. tan gry. 90% fn. xln. dolo., 10% med. calc. fracture fill and vug filling. Laminated. Few very fn. qtz. gns. Vuggy porosity - fossil molds, crinoids. Fe stain. Recryst. Beds massive.
90	f	SpC Cp71: dolo., pnk.-lt. brn. 90% fn. xln. rhomb. dolo., 10% med. calc. Laminated. Few qtz. gns. Argill. Fossils and molds. Vuggy porosity. Fe stains. Recryst. Vert. fractures, shearing. Beds 1-6".
90	f	SpC Cp72: dolo., lt. brn., weaths. gry. brn. 90% fn. xln. rhomb. dolo., 10% med. xln. calc. Pelletal. Laminated. Few qtz. gns. Mic. stringers and blebs. Spongy porosity - some lined with silica. Fe stain. 1-6" beds.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 12 of 16)



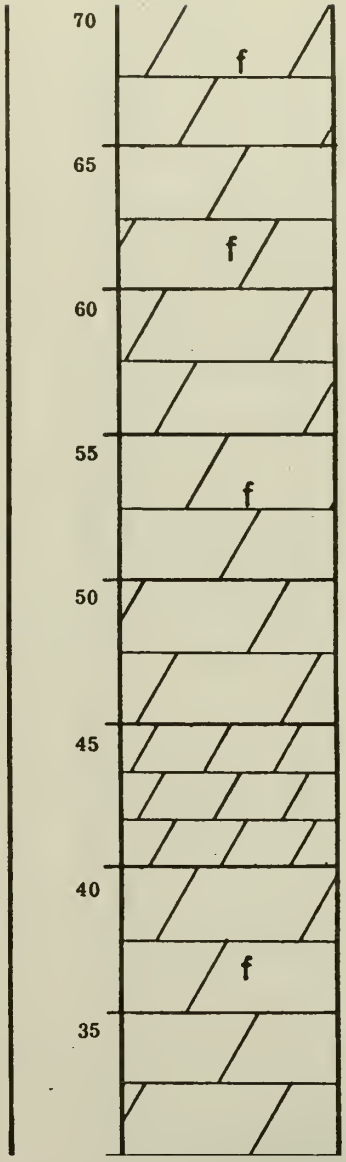
90	f	SpC Cp73: dolo., tan brn., weaths. brn. 90% fn. xln. rhomb. dolo., 10% med. xln. calc. Laminated. Pelletal. Mic. blebs and interclasts. Fossil molds-vuggy porosity. Argill. Fe stains. Recryst. 1/2-1" beds.
100	f	SpC Cp74: dolo., brn., weaths. gry. brn. 100% fn. xln. rhomb. dolo. Laminated. Few fossil milds. Fine intergranular porosity. Fe stain. Recryst. Beds, very massive.
98	f	SpC Cp75: dolo., Yel. brn. tan. 98% fn. xln. to mic. dolo., 2% calc. in masses and intergran. Few fn. qtz. gns. Argill. Mic. interclasts. Spongy porosity. Slight Fe stain. Recryst. Cherty. Thin beds.
100	f	SpC Cp76: dolo., tan lt. brn., weaths. yel. brn. 100% fn. xln. dolo. Pelletal. Laminated. Argill. Few qtz. gns. Intergran. porosity. Fe stain. Recryst. Beds very massive.
100	f	SpC Cp77: dolo., lt. brn. 100% fn. xln. sacc. dolo. Pelletal. Laminated. Slight argill. Few fossil molds. Slight Fe stain. Recryst. Beds massive.
100	f	SpC Cp78: dolo., brn., weaths. brn. gry. 100% fn. xln. dolo. Pelletal. Laminated. Vuggy and intergranular porosity. Fe stain-pyrite. Recryst. Beds 18-24".
95	f	SpC Cp79: dolo., brn. 95% fn. xln. dolo., 5% med. xln. calc. Pelletal. Argillaceous. Some vuggy porosity. Slight Fe stain. Recryst. Beds thin.
100	f	SpC Cp80: dolo., brn., weaths. brn. tan. 100% fn. xln. dolo. Pelletal. X-lam. Argill. Some qtz. gns. Spongy and intergran. por.-some silica lined. Fe stain. Recryst.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 13 of 16)



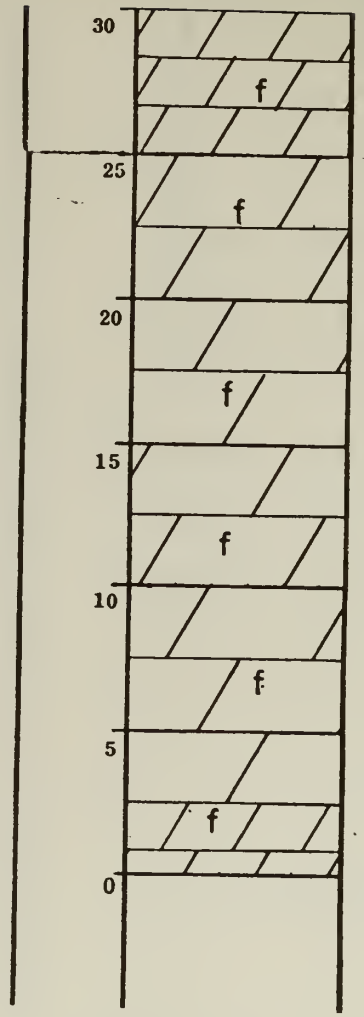
100	f-m	SpC Cp81: dolo., lt. brn., weaths. gry. brn. 100% fn. - med. xln. dolo. Laminated. Pelletal. Argill. Some silica lining vugs and pores. Intergran., and vuggy porosity. Some Fe stain. Recryst. Sheared, vert. fractures. Vert. Cliff. Beds 3-12".
100	f	SpC Cp82: dolo., lt. brn., weaths. gry. buff tan. 100% fn. xln. rhomb. dolo. Laminated. Pelletal. Argill. Some blebs of argill. mic. to 4 mm. Some Fe stain. Recryst. 6-12".
95	f	SpC Cp83: dolo., lt. brn., gry. streaks. 95% fn. xln. rhomb. dolo., 5% med. calc. Pelletal. Laminated. Few qtz. gns. Argill. - mic. blebs and stringers. Fossil molds-vuggy porosity. Fe stain. Recryst. Beds 24".
95	vf	SpC Cp84: dolo., lt. brn., weaths. gry. brn. 95% very fn. xln. dolo., 5% fn. xln. calc. Laminated - contorted. Argill. Fe stain. Calc. in fractures. Beds 12-24".
100	f	SpC Cp85: dolo., lt. brn., weaths. gry. brn. 100% fn. xln. dolo. Pelletal. Few mic. blebs. Slightly argill. Few ang. qtz. gns. Few fossil molds - slight porosity. Fractured and sheared.
100	f	SpC Cp86: dolo., brn. - pnk. 100% fn. xln. sacc. dolo. Slight Fe stain. Slight vuggy porosity. Few brachiopod relics. Recrysts. Beds 24".
100	f	SpC Cp87: dolo., brn-pnk. 100% fn. xln. sacc. dolo. Slightly argill. Some Fe stain - pyrite. Fossil molds - brachs. Recryst. Beds 24".
95	f	SpC Cp88: dolo., yel. brn., weaths. same. 95% fn. xln. rhomb. sacc., 5% fn. xln. calc. Slight argill. Some fossil molds - Brachs. Vuggy porosity. Slight Fe stain. Recryst. Beds 3'.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 14 of 16)



95	f	SpC Cp89: dolo., lt. brn., weaths. yel. brn. 95% fn. xln. rhomb. dolo., 5% med. xln. calc. Pelletal. Slightly argill. Few fossil molds. Some vuggy porosity. Slight Fe stain - pyrite. Recryst. Beds massive.
95	f	SpC Cp90: dolo., lt. brn., weaths. gry. buff. 95% fn. xln. rhomb. dolo., 5% med. xln. calc. Slightly argill. Fossil molds - slight vuggy porosity. Slight Fe stain. Recryst. Beds very massive.
95	f	SpC Cp91: dolo., lt. brn., weaths. gry. brn. 95% fn. xln. rhomb. dolo., 5% med. xln. calc. in blebs and fractures. Some qtz. gns. Slight argill. Some vuggy porosity. Slight Fe stain. Recryst. Beds very massive.
100	f	SpC Cp92: dolo., lt. brn., weaths. yel. brn. 100% fn. xln. rhomb. dolo. Few qtz. gns. X-lam. Slightly argill. Few fossil molds-vuggy porosity. Slight Fe stain. Recryst. Beds very massive.
100	f	SpC Cp93: dolo., lt. brn. weaths. gry. brn. 100% fn. xln. rhomb. dolo. X-lam. Very dense. Mn. gns. Slight vuggy porosity. Recryst. Beds very massive.
98	f	SpC Cp94: dolo., lt. brn., weaths. gry. brn. 98% fn. xln. rhomb. dolo., 2% med. xln. calc. Slightly argill. Mn. gns. some vuggy-spongy porosity. Recryst.
95	f	SpC Cp95: dolo., tan-pnk. mottled., weaths. gry. buff. 95% fn. xln. rhomb. dolo., 5% med. xln. calc. Fossil molds - vuggy porosity. Mn. gns. Some Fe stain. Recryst. Beds 4'.
100	f	SpC Cp96: dolo., gry. brn., weaths. brn. 100% fn. xln. rhomb. dolo. Argill. Some molds-vuggy porosity. Fe stain. Mn. gns. Recryst. Beds very massive.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 15 of 16)



100	f	SpC Cp97: dolo., brn., weaths. buff brn. 100% fn. xln. rhomb. dolo. Some qtz. gns. Pelletal. Fossil molds-vuggy porosity in zones. Mn. gns. Recryst.
98	f	SpC Cp98: dolo., 98% fn. xln. rhomb. dolo., 2% med. xln. calc. Slightly argill. Fossil molds, crinoids, vuggy porosity. Mn. gns. Fe stain. Recryst. Beds massive.
98	f	SpC Cp99: dolo., brn.-lt. pnk., weaths. brn. 98% fn. xln. rhomb. dolo., 2% med. xln. calc. Slightly argill. Fossil molds, crinoids and brachs - vuggy porosity. Mn. gns., some Fe stain. Recryst. Beds massive.
100	f	SpC Cp100: dolo., gry. brn., weaths. brn. 100% fn. xln. dolo. Slightly argill. Fossil molds, brachs, vuggy porosity. "Reefoid". Slight Fe stain. Recryst. Beds massive.
100	f	SpC Cp101: dolo., brn., weaths. brn. 100% fn. xln. dolo. Laminated. Some qtz. gns. Argill. Fossil molds - vuggy porosity. Some with silica lining. Some Fe stain. Mang. dends. Recryst. Beds 36".
100	f	SpC Cp102: dolo., brn., weaths., brn. 100% fn. xln. rhomb. dolo. Alter gry. and buff laminations. Argill. Fossil molds - vuggy porosity. Some silica in vugs. Fe stain. Mang. gns. Beds 6-18".
Englewood		Contact Argill. dolomite, purple, fn. xln. 5-10% qtz silt, x-lam. Chonchoidal fracture, color banded; purple red-brown. Weathers shaly to blocky. Sharp contact.

SPEARFISH CANYON SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 16 of 16)

Surface Section-Whitewood Dolomite

WHITEWOOD TYPE SECTION

Lawrence County, South Dakota

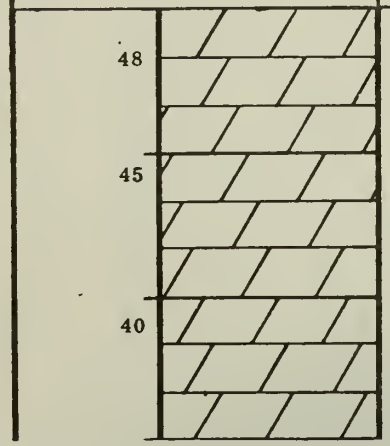
East of Deadwood, S.D. North of Hwy. 14A near Whitewood Cr.

E 1/2 of SW 1/4 Sec. 13, T5N, R3E

Vertical Scale: 1" = 5'

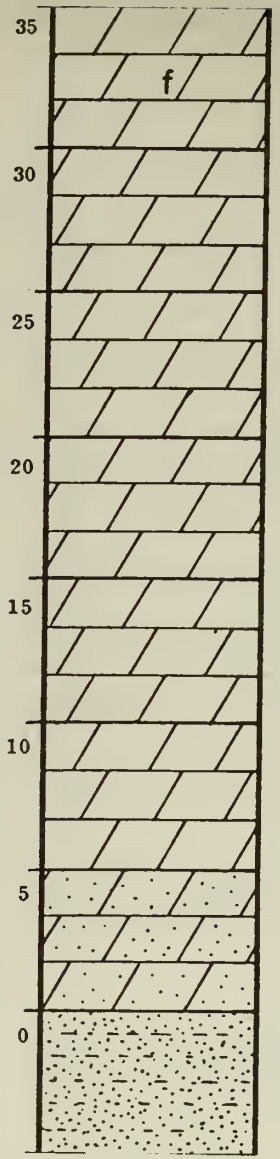
Dept. of Geol. & Geol. Eng., S.D.S.M.& T. 6/71

By: J.C.M., J.G., G.B.S., D.C.B.



	% Dolo.	Grain Size	
48	85	vfn.	Ow 24: dolo., yell.-brn., vfn. xln. sucrosic, shly, limey. mottled pink, fine pp. poro., few small vugs, vugs calc. & mang. filled, limon. stain, almost micro. xln.
45	90	fn.	Ow 23: dolo., yell.-brn., fn. xln. sucrosic w/ occl. clast of brown dolo., good pp. por., some vuggy poro., arg., some silica in vugs, pink orange arg. mottling.
40	90	fn.	Ow 22: dolo., yell.-brn. w/ pink mottling, fn. xln., sli. sucrosic, sli. arg., good pp. por., some vugs, mang. dendrites inter xln. calc. cement, Fe stain, pores, occl. spar., good rhombs.

WHITEWOOD DOLOMITE TYPE SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 1 of 2)



90	fn.	Ow 21: dolo., brn. pink mottling, fn. xln. sucrosic, v. sli. calc., pp. poro., some vuggy poro., arg., Mang. dendrites, local pink dolo. clasts, brach, occl. wh. spar., Fe stain, occl. grain qtz. silt.
90	vfn.-fn.	Ow 20: dolo., yell. brn., pink mottled, vfn. xln.-fn. sucrosic, small pink dolo. clasts, some limey inter xln. cement, some vuggy por., textural blebs, arg., limon. stain, occl. grain qtz. silt, occl. silica vug, occl. spar.
90	fn.-vfn.	Ow 19: dolo., yell. brn., mottled pink tan, fn.-vfn. xln. sucrosic arg., some inter xln. por., pp. por., few vugs, occl. grain qtz. silt, limon. stain, calc. frac. fill, pelletal?
90	vfn.-fn.	Ow 18: dolo., yell. brn. mottled w/ pink, vfn.-fn. xln. sucrosic, pp. pores, stylolite, mang. stain along fracs., small vugs, occl. spar., arg., limon. stain, 1% qtz. silt.
90	vfn.-fn.	Ow 17: dolo., yell.-brn. w/ pink mottling, vfn.-fn. sucrosic, arg., pp. por., few small vugs, faint lam.? limonite stain.
85	vfn.-fn.	Ow 16: silty dolo., yell.-brn. w/ pink mottling, vfn.-fn. xln. sucrosic, arg., pp. por., few small vugs, faint lam., limon. stain, 5% qtz. silt, arg., w/ some calc. cement in places.
50	vfn.	Ow 15: silty dolo., yell.-brn, vfn.-xln., & gry. tan lam. w/ colored bedding, bioturbidated? w/ qtz. silt 35%, Fe stain, at base of interval.
		ROUGHLOCK
0	vfn.-silt.	Ow 14: siltstone, gry.-redish gry., vfn.-silt qtz., arg. sli. calc., lam? Contorted lam., worm borrows? Fe stain.

WHITEWOOD DOLOMITE TYPE SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 2 of 2)

Surface Section - Pahasapa Limestone

RHOADES RANCH

Pennington County, South Dakota

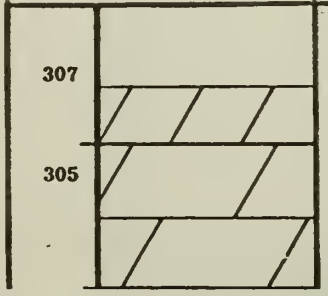
Center of E1/2, Sec. 16, R2E, T2N

South Fork, Rapid Creek, North Side Road 233

Vertical scale: 1" = 5'

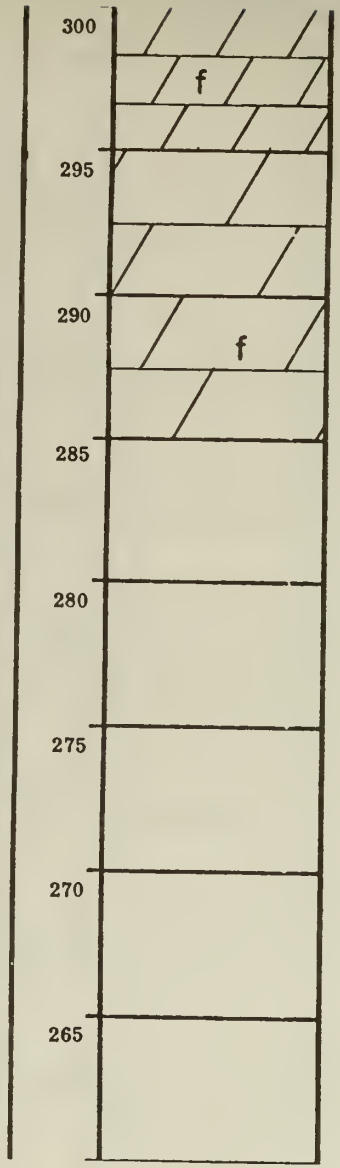
Dept. of Geol. & Geol. Eng., S.D.S.M.&T. 7 / 71

By: J.C.M., D.C.B.



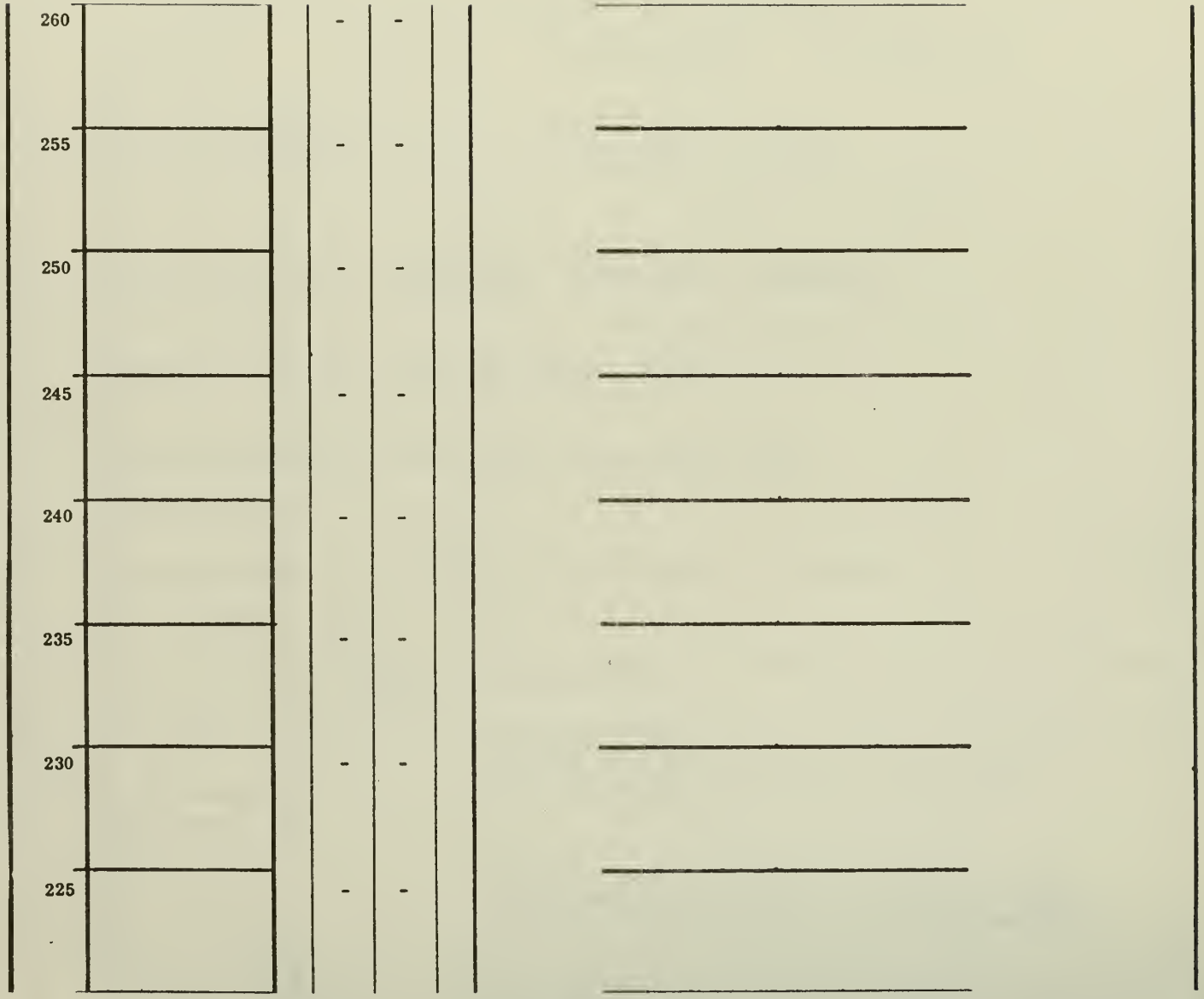
	% Dolo.	Grain Size	
307	-	-	Dolomite. Top of hill.
305	95	m-c	Cp 33 RR: dolo., gry. wh. 95% med.-crs. rhomb. sacc. dolo. 2-3% med.-crs. intergrn. and blebs calc. Argillaceous. Recryst. Intergranular porosity. Fe stain. Mn gns. and dendrites, 1-2%. Beds massive.

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 1 of 9)

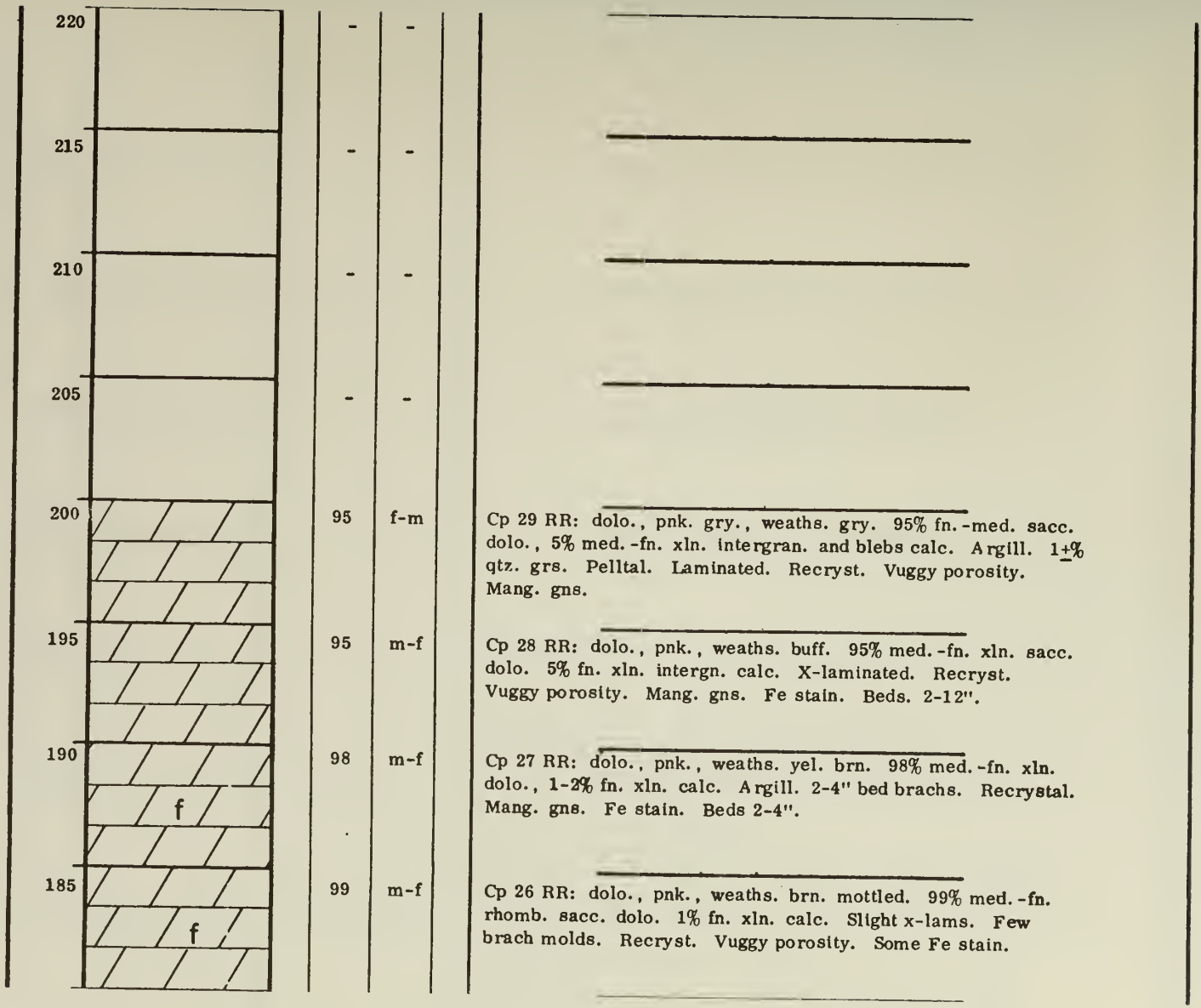


90	f-c	Cp 32 RR: dolo. 90% fn.-crs. rhomb. sacc. dolo. 10% fn.-crs. intergran. and blebs calc. Argillaceous. Few fossil molds-vuggy porosity. Recryst. Mang. gns. Fe stain.
90	f-c	Cp 31 RR: dolo., wh. gry. 90% fn.-crs. sacc. dolo. 10% fn.-crs. intergranular and vugs calc. Argill. Slightly x-bedded. Recryst. Vuggy-intergranular porosity. Mang. gns. Beds massive.
95	f-c	Cp 30 RR: dolo., lt. yel. brn. 95% fn.-crs. sacc. dolo. 5% fn.-crs. intergran. and blebs calc. Argill. Pelletal. Few fossil molds-vuggy porosity. Recryst. Fe stain. Beds massive, indistinct.
-	-	Covered interval.
-	-	
-	-	
-	-	
-	-	
-	-	

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 2 of 9)

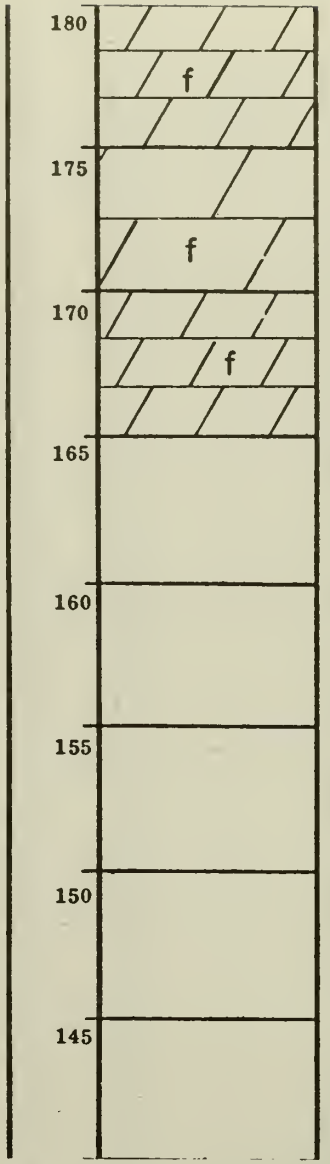


RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 3 of 9)



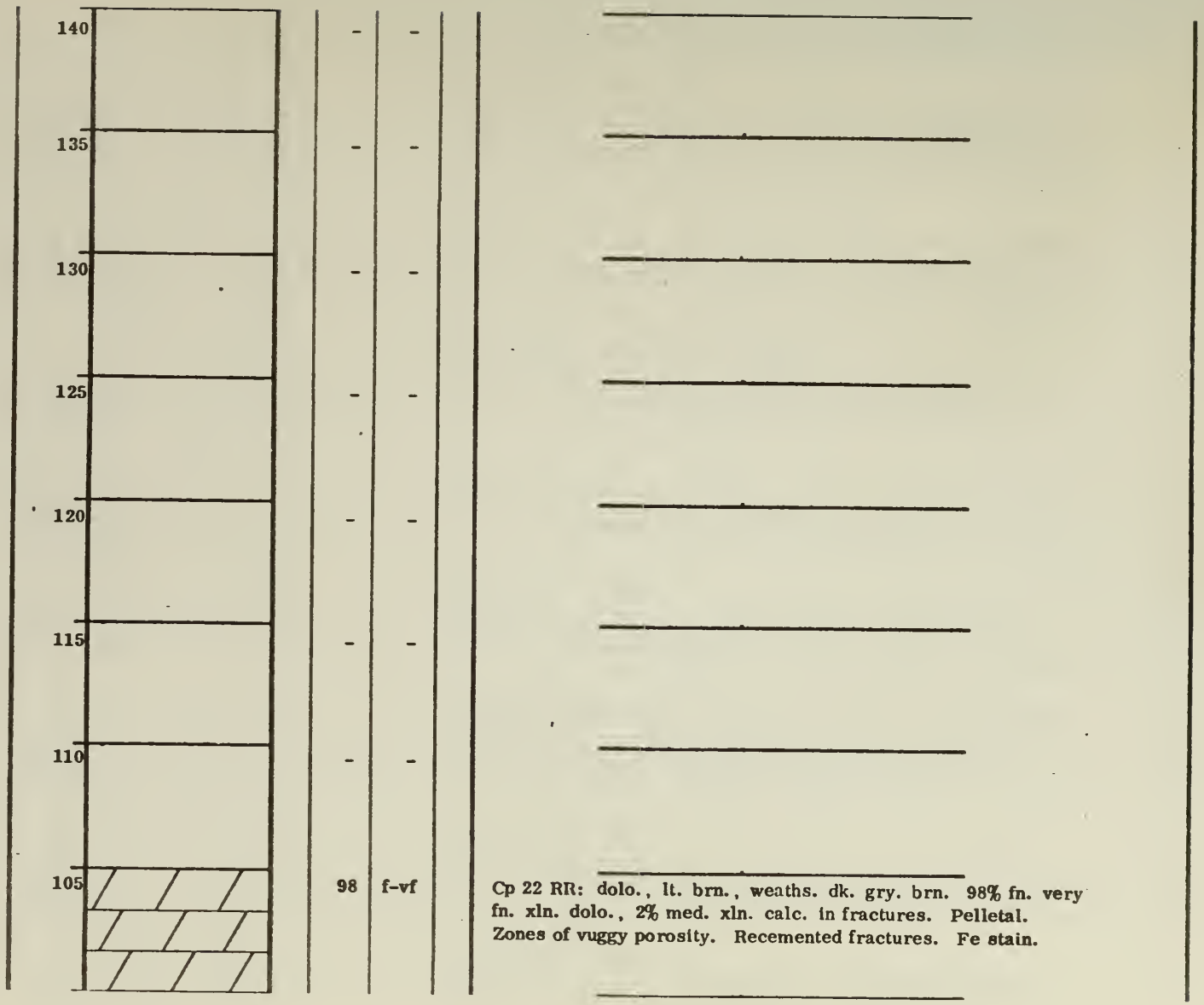
220	-	-	
215	-	-	
210	-	-	
205	-	-	
200	95	f-m	Cp 29 RR: dolo., pnk. gry., weaths. gry. 95% fn.-med. sacc. dolo., 5% med.-fn. xln. intergran. and blebs calc. Argill. 1±% qtz. grs. Pelltal. Laminated. Recryst. Vuggy porosity. Mang. gns.
195	95	m-f	Cp 28 RR: dolo., pnk., weaths. buff. 95% med.-fn. xln. sacc. dolo. 5% fn. xln. intergn. calc. X-laminated. Recryst. Vuggy porosity. Mang. gns. Fe stain. Beds. 2-12".
190	98	m-f	Cp 27 RR: dolo., pnk., weaths. yel. brn. 98% med.-fn. xln. dolo., 1-2% fn. xln. calc. Argill. 2-4" bed brachs. Recrystal. Mang. gns. Fe stain. Beds 2-4".
185	99	m-f	Cp 26 RR: dolo., pnk., weaths. brn. mottled. 99% med.-fn. rhomb. sacc. dolo. 1% fn. xln. calc. Slight x-lams. Few brach molds. Recryst. Vuggy porosity. Some Fe stain.

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 4 of 9)

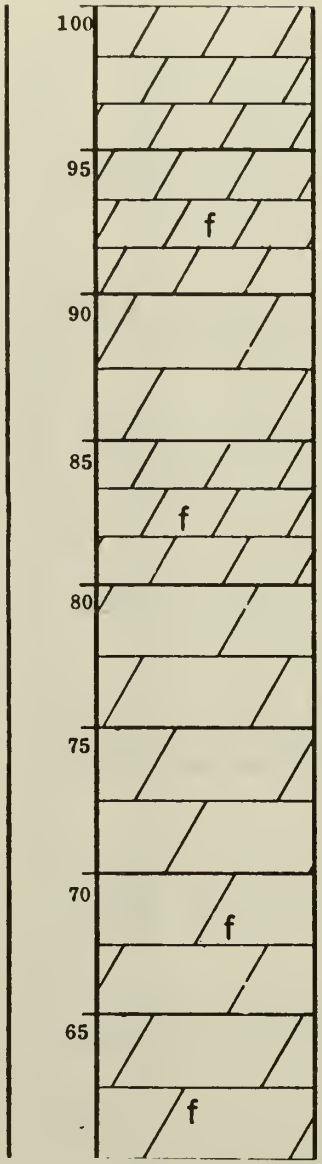


98	f-m	Cp 25 RR: dolo., pnk. 98% fn.-med. sacc. dolo. 1-2% fn. intergranular calc. Argill. Laminated. Brachs. Recryst. Vuggy-intergran. porosity. Fe stain.
95	f-m	Cp 24 RR: dolo., lt. yel. brn., weaths. gry. 95% fn. med. dolo. 5% fn. xln. intergrn. calc. Argill. Pelletal. Laminated. Recryst. Crinoids-molds. Vuggy porosity. Some silica vug fill. Fe stain. Beds massive.
95	f	Cp 23 RR: dolo., Lt. pnk. brn., weaths. yel. brn. 95% fn. xln. calc. in brach molds. Argill. Stringers of clay and dolomite. Pelletal-dismic. Recryst. Fe stain. Beds 6-12".
-	-	Covered interval.
-	-	
-	-	
-	-	
-	-	

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 5 of 9)

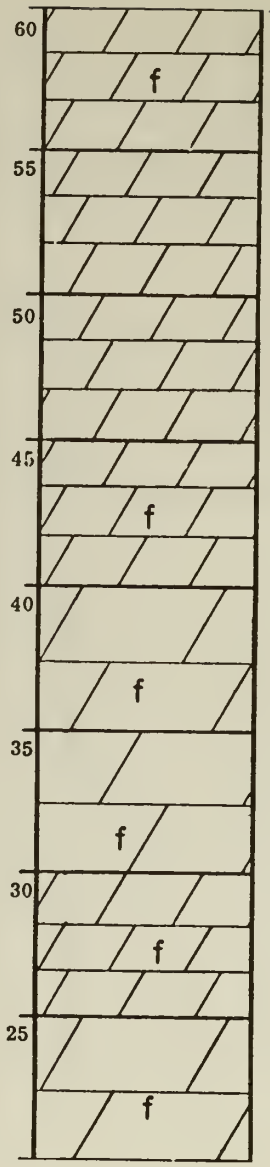


RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 6 of 9)



99	f	Cp 21 RR: dolo., lt. brn., weaths. dk. gry. brn. 99% fn. xln. sacc. dolo. Pelletal. Slightly argill. Vuggy-spongy porosity. Mang. gns. Fe stain.
95	f	Cp 20 RR; dolo., lt. brn., weaths. dk. gry. brn. 95% fn. xln. dolo., 5% fn. intergrn. and crs. vug fill calc. Argill. Fossil molds-vuggy porosity.
99	f	Cp 19 RR: dolo., lt. brn., weaths. gry. 99% fn. xln. dolo., 1% intergrn. and vug calc. Argill. Pelletal. Recryst. Zones of vuggy-spongy porosity. Mang. gns. Fe stain. Beds massive.
99	f	Cp 18 RR: dolo., lt., brn., weaths. gry. 99% fn. xln. dolo., 1% fn. xln. vug fill calc. Argill. streaks. Fossil molds-vugs. Mang. gns. Fe stain.
98	f	Cp 17 RR: dolo., lt. brn., weaths. gry. 98% fn. xln. dolo., 2% fn. xln. intergrn. calc. Argill. Mang. gns. Beds very massive.
98	f	Cp 16 RR: dolo., 98% fn. xln. dolo., 1% fn. xln. intergrn.-vug calc. Argill. Few qtz. gns. Recryst. some vuggy porosity. Mang. gns. and CO_3? Beds massive.
98	f	Cp 15 RR: dolo., brn. pnk., weaths. gry. 98% fn. xln. sacc., dolo., 1-2% fn. xln. intergran. calc. Argill. Few crinoid molds. Recryst. Mang. gns. and Co_3? Beds massive.
95	f	Cp 14 RR: dolo., lt. brn., weaths. gry. brn. 95% fn. xln. dolo., 5% fn. xln. intergrn. calc. Argill. Few crinoid molds-slight vuggy-spongy porosity. Mang gns. Bed 3'.

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 7 of 9)



60	95	f
55	95	f
50	98	f
45	98	f
40	98	f
35	98	f
30	95	f
25	98	f

Cp 13 RR: dolo., 95% fn. xln. sacc. dolo. 5% fn. xln. intergranular. Slightly argill. Pelletal. Few crinoid molds-vuggy porosity. Recryst. Mang. gns.

Cp 12 RR: dolo., lt. yel. brn., weaths. yel. gry. 95% fn. xln. sacc. dolo., 5% fn. xln. intergran. calc. Coral. Intergran.-vuggy porosity. Fe stain. Beds 6-12".

Cp 11 RR: dolo., lt. yel. brn., weaths. gry. 98% fn. xln. dolo., 2% fn. xln. dolo., 2% fn. xln. vug calc. Pelletal-lumps. Stringers of Fe-clay. Few qtz. gns. Recryst. Slight vuggy porosity. Mang. gns. Fe stain.

Cp 10 RR: dolo., yel. brn., weaths. lt. brn. 98% fn. xln. sacc. dolo., 1-2% fn. xln. intergrn. and med. vug calc. Argill. Crinoids, horn coral. Recryst. Some vuggy porosity. Mang. dends. Beds 3-6".

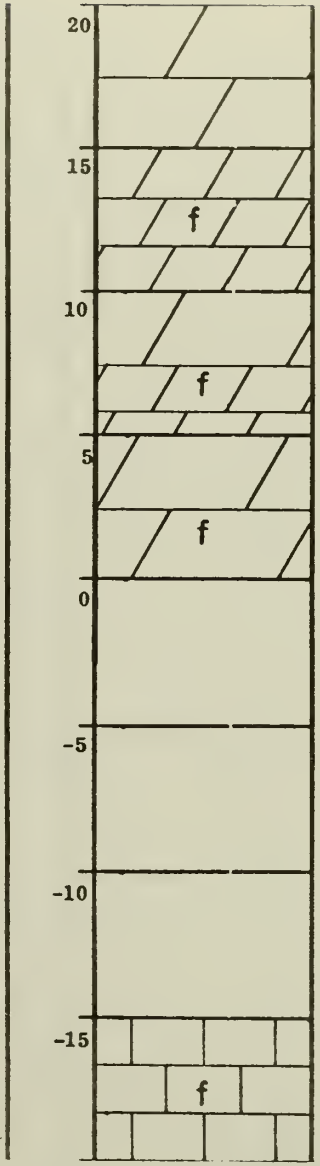
Cp 9 RR: dolo., yel. brn., weaths. gry. 98% fn. xln. sacc. dolo., 1-2% fn. xln. calc. Argill. Few qtz. gns. Crinoid molds. Vuggy porosity. Mang. gns. Fe stain. Beds massive.

Cp 8 RR: dolo., gry. brn., weaths. gry. 98% fn. xln. dolo. 1-2% fn. xln. intergrn. calc. Argill. streaks. Some crinoid molds-vuggy porosity in zones. Mang. gns. Fe stain. Beds 1-3'.

Cp 7 RR: dolo., yel. brn., weaths. gry. brn. 95% fn. xln. dolo., 5% fn. xln. intergrn. calc. Pelletal. Slightly argill. Some silica in vugs. Fossil molds-vuggy porosity. "Reefoid".

Cp 6 RR: dolo., lt. gry. brn., 98% fn. xln. dolo., 1-2% fn. xln. intergrn. calc. Slightly argill. Fossil molds-crinoids-vuggy-spongy porosity. Stylolites. Fe stain. Beds massive.

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 8 of 9)



98	f	Cp 5 RR: dolo., lt. brn., weaths. dk. gry. orgn. 98% fn. xln. dolo., 1-2% fn. xln. intergrn. and vug fill calc. Slightly argill. Little qtz. silt. Molds-vuggy-spongy porosity. "Reefoid". Beds massive.
98	f	Cp 4 RR: dolo., lt. brn., weaths. yel. orng. 98% fn. xln. dolo., 1-2% med. xln. calc. Argill. Pelletal. Little qtz. silt. Crinoid molds.-vuggy porosity.
95	f	Cp 3 RR; dolo., lt. brn., weaths. gry. brn. orgn. 95% fn. xln. dolo. 5% fn. xln. calc. Argillaceous. Crinoid molds-vuggy porosity. Fe stain. Beds 2"-3'.
90	f	Cp 2 RR: dolo., lt. yel. brn., weaths. gry. brn. 95% fn. xln. dolo., 5% fn. xln. calc. Some silica. Argill. Hematitic. Crinoids-vugs. Beds 2-3'.
		Covered interval. Could be C_e or C_p.
15	f	Cp 1 RR: Englewood. Ls., argillaceous. Buff gry.-maroon. 75% fn. xln. calc., 15% fn. xln. dolo. 5% clay, 1-3% qtz. silt, 1-2% hematite. Brachs, bry., coral, crinoids-some replaced with hematite. Mang. dendrites.

RHOADES RANCH SECTION, BLACK HILLS, SOUTH DAKOTA (Sheet 9 of 9)

APPENDIX E

EXPERIMENTAL DATA FOR SODIUM REMOVAL FROM LIGNITE BY ION EXCHANGE

The experimental data presented in the tables in this appendix are described, interpreted, and presented in graphic form in Subsection 7.2 of Book 1 of this volume.

DATA ON STIRRED BATCH EXPERIMENTS: TABLES E-1 through E-31

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 6.2 pH, 3 to 6°C, -14+20 mesh.

CONTACT TIME	% SODIUM REMOVED
30 minutes	6.4
60 minutes	6.4
75 minutes	8.9
90 minutes	8.9
120 minutes	7.7

Table E-1. DATA FOR FIGURE 7-24

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 6.3 pH, 23°C, -14+20 mesh.

CONTACT TIME	% SODIUM REMOVED
30 minutes	22.0
60 minutes	22.0
75 minutes	20.5
90 minutes	24.5
120 minutes	20.0

Table E-2. DATA FOR FIGURE 7-24

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-1} molar $CaCl_2$, 6.5 pH, 3 to 6°C, -14+20 mesh.

CONTACT TIME	% SODIUM REMOVED
90 minutes	56.0
120 minutes	61.5
150 minutes	61.5

Table E-3. DATA FOR FIGURE 7-25

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-1} molar $CaCl_2$, 6.5 pH, 23°C, -14+20 mesh.

CONTACT TIME	% SODIUM REMOVED
15 minutes	57.5
30 minutes	76.0
60 minutes	83.0
90 minutes	83.0
120 minutes	88.5
150 minutes	88.0

Table E-4. DATA FOR FIGURE 7-25

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 300 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 23°C, -10+14 mesh.

	pH	% SODIUM REMOVED
Distilled H_2O	3.0	15.5
	4.0	18.0
	4.9	15.5
	5.4	17.0
	6.0	16.8
$CaCl_2=10^{-3}$ molar	3.3	28.5
	4.0	24.5
	4.3	22.0
	5.4	22.0
	5.7	19.0
$CaCl_2=10^{-1}$ molar	3.4	83.0
	4.4	81.0
	4.9	70.5
	6.7	70.5
	8.0	70.5

Table E-5. DATA FOR FIGURE 7-26

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 300 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 10^{-1} molar $CaCl_2$, 3 to 6°C, -14+20 mesh.

pH	% SODIUM REMOVED
3.2	75.5
5.3	73.5
8.0	72.5

Table E-6. DATA FOR FIGURE 7-27

Sodium removal from Beulah, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 300 ML of solution. The lignite slurries were stirred for 2 hours at a temperature of 23°C.

MESH	pH	$CaCl_2$ CONCENTRATION	% SODIUM REMOVED
-6+10	6.0	10^{-3} molar	20.5
-14+20	5.7	10^{-3} molar	24.0
-20	5.7	10^{-3} molar	31.0
-6+10	5.9	Distilled H_2O	17.0
-14+20	5.7	Distilled H_2O	20.5
-20	5.7	Distilled H_2O	24.5
-6+10	3.1	10^{-3} molar	25.0
-14+20	3.1	10^{-3} molar	26.5
-20	3.1	10^{-3} molar	34.5
-6+10	3.1	Distilled H_2O	17.0
-14+20	3.1	Distilled H_2O	29.0
-20	3.1	Distilled H_2O	29.0

Table E-7. DATA FOR FIGURE 7-28

Sodium removal from Glenharold lignite, Stanton, North Dakota, by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: Distilled H_2O, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1 hour	1.15
-8+14	2 hour	2.30
-8+14	4 hour	3.44
-8+14	8 hour	4.21
-14+28	1 hour	3.06
-14+28	2 hour	4.21
-14+28	4 hour	4.98
-28+48	1 hour	4.59
-28+48	2 hour	6.89
-28+48	4 hour	9.18
-28+48	8 hour	9.18

Table E-8. DATA FOR FIGURE 7-29

Sodium removal from Glenharold lignite, Stanton, North Dakota, by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	6.52
-8+14	1/2 hour	6.13
-8+14	1 hour	4.60
-8+14	2 hour	5.74
-8+14	4 hour	9.58
-14+28	1/4 hour	7.28
-14+28	1 hour	7.65
-14+28	2 hour	7.65
-14+28	4 hour	12.24
-28+48	1/4 hour	8.05
-28+48	1/2 hour	7.66
-28+48	1 hour	9.55
-28+48	2 hour	9.55
-28+48	4 hour	12.24

Table E-9. DATA FOR FIGURE 7-30

Sodium removal from Glenharold lignite, Stanton, North Dakota, by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 24°C, -8+14 mesh.

pH	MOLAR Concentration	% SODIUM REMOVED
4.0	$CaCl_2=10^{-3}$	7.6
6.1	$CaCl_2=10^{-3}$	7.6
7.9	$CaCl_2=10^{-3}$	6.8
4.0	$CaCl_2=10^{-1}$	63.5
5.8	$CaCl_2=10^{-1}$	62.0
7.9	$CaCl_2=10^{-1}$	61.5
5.8	$MgCl_2=10^{-3}$	16.5
7.5	$MgCl_2=10^{-3}$	13.0
4.0	$MgCl_2=10^{-1}$	64.3
6.0	$MgCl_2=10^{-1}$	62.0
7.9	$MgCl_2=10^{-1}$	59.7

Table E-10. DATA FOR FIGURE 7-31

Sodium removal from Glenharold lignite, Stanton, North Dakota, by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 3 to 6°C, -14+20 mesh.

pH	$CaCl_2$ CONCENTRATION	% SODIUM REMOVED
3.1	10^{-1} molar	73.5
6.3	10^{-1} molar	69.0
3.0	10^{-3} molar	13.0
6.3	10^{-3} molar	10.5
3.2	Distilled H_2O	3.8
3.7	Distilled H_2O	3.4
5.9	Distilled H_2O	2.7

Table E-11. DATA FOR FIGURE 7-32

Sodium removal from Glenharold lignite, Stanton, North Dakota, by ion exchange in agitated slurries having 50 GM of lignite in 300 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 3 to 6°C, -14+20 mesh.

pH	$CaCl_2$ CONCENTRATION	% SODIUM REMOVED
3.1	10^{-3} molar	11.5
4.0	10^{-3} molar	8.2
6.9	10^{-3} molar	9.1
3.1	Distilled H_2O	4.6
4.2	Distilled H_2O	0.3
5.9	Distilled H_2O	0.3

Table E-12. DATA FOR FIGURE 7-33

Sodium removal from Glenharold lignite, Stanton, North Dakota, by ion exchange in agitated slurries. The slurries had 25 GM of lignite in different weight ratios of solution and were stirred for 2 hours under the following conditions: 10^{-1} molar $CaCl_2$, 24°C, -8+14 mesh.

SOLID:LIQUID RATIO	% SODIUM REMOVED
1:1	33.1
1:3	65.0
1:6	92.0
1:12	104.0

Table E-13. DATA FOR FIGURE 7-34

Sodium removal from Burke County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: Distilled H_2O, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1 hour	3.25
-8+14	2 hour	3.25
-8+14	4 hour	5.01
-8+14	8 hour	5.68
-14+28	1 hour	6.32
-14+28	2 hour	6.45
-14+28	4 hour	5.68
-28+48	1 hour	8.93
-28+48	2 hour	9.20
-28+48	4 hour	9.74
-28+48	8 hour	9.74

Table E-14. DATA FOR FIGURE 7-35

Sodium removal from Burke County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	2.27
-8+14	1/2 hour	2.68
-8+14	1 hour	4.16
-8+14	2 hour	4.83
-8+14	4 hour	3.22
-14+28	1/4 hour	4.45
-14+28	1/2 hour	4.05
-14+28	1 hour	8.00
-14+28	2 hour	9.45
-14+28	4 hour	5.55
-28+48	1/4 hour	7.30
-28+48	1/2 hour	7.30
-28+48	1 hour	8.40
-28+48	2 hour	9.45
-28+48	4 hour	6.20

Table E-15. DATA FOR FIGURE 7-36

Sodium removal from Burke County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	0.54
-8+14	1/2 hour	1.08
-8+14	1 hour	1.76
-8+14	2 hour	3.38
-8+14	4 hour	2.30
-14+28	1/4 hour	4.20
-14+28	1/2 hour	4.75
-14+28	1 hour	6.36
-14+28	2 hour	8.93
-14+28	4 hour	9.20
-28+48	1/4 hour	6.50
-28+48	1/2 hour	6.90
-28+48	2 hour	8.93
-28+48	4 hour	10.15

Table E-16. DATA FOR FIGURE 7-37

Sodium removal from Burke County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 24°C, -8+14 mesh.

pH	MOLAR CONCENTRATION	% SODIUM REMOVED
6.2	$CaCl_2=10^{-3}$	8.25
8.0	$CaCl_2=10^{-3}$	4.55
4.1	$CaCl_2=10^{-1}$	36.30
6.0	$CaCl_2=10^{-1}$	36.30
8.0	$CaCl_2=10^{-1}$	33.30
4.1	$MgCl_2=10^{-3}$	4.87
6.1	$MgCl_2=10^{-3}$	4.33
8.2	$MgCl_2=10^{-3}$	3.92
4.1	$MgCl_2=10^{-1}$	37.89
6.2	$MgCl_2=10^{-1}$	37.89
8.0	$MgCl_2=10^{-1}$	36.54

Table E-17. DATA FOR FIGURE 7-38

Sodium removal from Burke County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 3 to 6°C, -8+14 mesh.

pH	MOLAR CONCENTRATION	% SODIUM REMOVED
4.1	$CaCl_2=10^{-3}$	4.43
6.2	$CaCl_2=10^{-3}$	4.55
8.0	$CaCl_2=10^{-3}$	3.22
4.1	$CaCl_2=10^{-1}$	34.30
6.0	$CaCl_2=10^{-1}$	33.40
8.0	$CaCl_2=10^{-1}$	31.80
4.1	$MgCl_2=10^{-3}$	4.47
6.1	$MgCl_2=10^{-3}$	3.38
8.2	$MgCl_2=10^{-3}$	2.71
6.2	$MgCl_2=10^{-1}$	28.42
8.0	$MgCl_2=10^{-1}$	27.74

Table E-18. DATA FOR FIGURE 7-39

Sodium removal from Burke County, North Dakota, lignite by ion exchange in agitated slurries. The slurries had 25 GM of lignite in different weight ratios of solution and were stirred for 2 hours under the following conditions: 10^{-1} molar $CaCl_2$, 5.9 pH, 24°C, -8+14 mesh.

SODIUM:LIQUID RATIO	% SODIUM REMOVED
1:1	11.6
1:3	37.4
1:6	53.0
1:12	69.5
1:24	71.5

Table E-19. DATA FOR FIGURE 7-40

Sodium removal from Bowman County, North Dakota, lignite by ion exch in agitated slurries having 50 GM of lignite in 150 ML of solution. lignite slurries were stirred for varying times under the following tions: Distilled H_2O, 7.8 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1 hour	38.25
-8+14	2 hour	29.25
-8+14	4 hour	38.25
-8+14	8 hour	47.25
-14+28	1 hour	40.50
-14+28	2 hour	40.50
-14+28	4 hour	42.75
-28+48	1 hour	42.75
-28+48	2 hour	47.25
-28+48	4 hour	47.25
-28+48	8 hour	47.25

Table E-20. DATA FOR FIGURE 7-41

Sodium removal from Bowman County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 8.1 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	44.7
-8+14	1/2 hour	46.0
-8+14	1 hour	46.0
-8+14	2 hour	40.0
-8+14	4 hour	48.3
-14+28	1/4 hour	42.5
-14+28	1/2 hour	48.3
-14+28	1 hour	48.3
-14+28	2 hour	46.0
-14+28	4 hour	48.3
-28+48	1/4 hour	44.8
-28+48	1/2 hour	53.5
-28+48	1 hour	48.3
-28+48	2 hour	48.3
-28+48	4 hour	60.5

Table E-21. DATA FOR FIGURE 7-42

Sodium removal from Bowman County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $MgCl_2$, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	33.75
-8+14	1/2 hour	38.25
-8+14	1 hour	41.62
-8+14	2 hour	38.25
-8+14	4 hour	46.13
-14+28	1/4 hour	42.75
-14+28	1/2 hour	49.38
-14+28	1 hour	42.75
-14+28	2 hour	37.13
-14+28	4 hour	46.13
-28+48	1/4 hour	45.00
-28+48	1/2 hour	49.38
-28+48	1 hour	55.13
-28+48	2 hour	49.38
-28+48	4 hour	49.38

Table E-22. DATA FOR FIGURE 7-43

Sodium removal from Bowman County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 24°C, -8+14 mesh.

pH	MOLAR CONCENTRATION	% SODIUM REMOVED
4.0	$CaCl_2=10^{-3}$	47.6
6.0	$CaCl_2=10^{-3}$	48.3
8.1	$CaCl_2=10^{-3}$	47.6
4.0	$CaCl_2=10^{-1}$	69.0
6.0	$CaCl_2=10^{-1}$	69.0
8.0	$CaCl_2=10^{-1}$	69.0
4.0	$MgCl_2=10^{-3}$	48.0
8.0	$MgCl_2=10^{-3}$	48.0
4.0	$MgCl_2=10^{-1}$	59.6
6.0	$MgCl_2=10^{-1}$	59.6
8.0	$MgCl_2=10^{-1}$	59.6

Table E-23. DATA FOR FIGURE 7-44

Sodium removal from Bowman County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 3 to 6°C, -8+14 mesh.

pH	MOLAR CONCENTRATION	% SODIUM REMOVED
4.0	$CaCl_2=10^{-3}$	44.8
6.0	$CaCl_2=10^{-3}$	46.0
8.0	$CaCl_2=10^{-3}$	34.6
4.0	$CaCl_2=10^{-1}$	69.0
6.0	$CaCl_2=10^{-1}$	66.5
8.0	$CaCl_2=10^{-1}$	73.5
4.0	$MgCl_2=10^{-3}$	42.8
6.0	$MgCl_2=10^{-3}$	45.0
8.0	$MgCl_2=10^{-3}$	47.1
4.0	$MgCl_2=10^{-1}$	64.1
6.0	$MgCl_2=10^{-1}$	68.6
8.0	$MgCl_2=10^{-1}$	66.4

Table E-24. DATA FOR FIGURE 7-45

Sodium removal from Bowman County, North Dakota, lignite by ion exchange in agitated slurries. The slurries had 25 GM of lignite in different weight ratios of solution and were stirred for 2 hours under the following conditions: 10^{-1} molar $CaCl_2$, 24°C, 6.0 pH.

SOLID:LIQUID RATIO	% SODIUM REMOVED
1:1	41.5
1:3	87.5
1:6	86.0
1:12	95.0
1:24	82.0

Table E-25. DATA FOR FIGURE 7-46

Sodium removal from Ward County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: Distilled H_2O, 8.2 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1 hour	36.0
-8+14	2 hour	36.0
-8+14	4 hour	37.8
-8+14	8 hour	39.6
-14+28	1 hour	36.0
-14+28	2 hour	37.8
-14+28	4 hour	40.2
-14+28	8 hour	37.8
-28+48	1 hour	39.6
-28+48	2 hour	40.8
-28+48	4 hour	37.8
-28+48	8 hour	43.2

Table E-26. DATA FOR FIGURE 7-47

Sodium removal from Ward County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $CaCl_2$, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	38.8
-8+14	1/2 hour	43.5
-8+14	1 hour	47.6
-8+14	2 hour	47.0
-8+14	4 hour	47.6
-14+28	1/4 hour	36.9
-14+28	1/2 hour	40.5
-14+28	1 hour	49.0
-14+28	2 hour	49.0
-14+28	4 hour	50.6
-28+48	1/4 hour	41.0
-28+48	1/2 hour	40.5
-28+48	1 hour	47.0
-28+48	2 hour	47.6
-28+48	4 hour	53.0

Table E-27. DATA FOR FIGURE 7-48

Sodium removal from Ward County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for varying times under the following conditions: 10^{-3} molar $MgCl_2$, 8.0 pH, 24°C.

MESH SIZE	CONTACT TIME	% SODIUM REMOVED
-8+14	1/4 hour	40.8
-8+14	1/2 hour	42.6
-8+14	1 hour	46.2
-8+14	2 hour	48.0
-8+14	4 hour	46.2
-14+28	1/4 hour	44.4
-14+28	1/2 hour	49.2
-14+28	1 hour	52.8
-14+28	2 hour	53.4
-14+28	4 hour	49.2
-28+48	1/4 hour	47.4
-28+48	1 hour	55.2
-28+48	2 hour	51.6
-28+48	4 hour	51.6

Table E-28. DATA FOR FIGURE 7-49

Sodium removal from Ward County, North Dakota, lignite by ion exchan; in agitated slurries having 50 GM of lignite in 150 ML of solution. lignite slurries were stirred for 2 hours under the following condit 24°C, -8+14 mesh.

pH	MOLAR CONCENTRATION	% SODIUM REMOVED
4.0	$CaCl_2=10^{-3}$	37.4
6.0	$CaCl_2=10^{-3}$	37.4
8.0	$CaCl_2=10^{-3}$	35.0
4.0	$CaCl_2=10^{-1}$	70.0
6.0	$CaCl_2=10^{-1}$	68.9
8.0	$CaCl_2=10^{-1}$	70.0
4.0	$MgCl_2=10^{-3}$	37.4
6.0	$MgCl_2=10^{-3}$	36.3
8.0	$MgCl_2=10^{-3}$	36.3
4.0	$MgCl_2+10^{-1}$	57.0
6.0	$MgCl_2=10^{-1}$	51.3
8.0	$MgCl_2=10^{-1}$	56.0

Table E-29. DATA FOR FIGURE 7-50

Sodium removal from Ward County, North Dakota, lignite by ion exchange in agitated slurries having 50 GM of lignite in 150 ML of solution. The lignite slurries were stirred for 2 hours under the following conditions: 3 to 6°C, -8+14 mesh.

pH	MOLAR CONCENTRATION	% SODIUM REMOVED
4.0	$CaCl_2=10^{-3}$	34.8
6.0	$CaCl_2=10^{-3}$	33.0
8.0	$CaCl_2=10^{-3}$	33.8
4.0	$CaCl_2=10^{-1}$	58.5
6.0	$CaCl_2=10^{-1}$	58.5
8.0	$CaCl_2=10^{-1}$	58.5
4.0	$MgCl_2=10^{-3}$	34.8
6.0	$MgCl_2=10^{-3}$	31.2
8.0	$MgCl_2=10^{-3}$	30.0
4.0	$MgCl_2=10^{-1}$	55.8
6.0	$MgCl_2=10^{-1}$	54.0
8.0	$MgCl_2=10^{-1}$	55.8

Table E-30. DATA FOR FIGURE 7-51

Sodium removal from Ward County, North Dakota, lignite by ion exchange in agitated slurries. The slurries had 25 GM of lignite in different weight ratios of solution and were stirred for 2 hours under the following conditions: 10^{-1} molar $CaCl_2$, 24°C, 6.0 pH, -8+14 mesh.

SOLID:LIQUID RATIO	% SODIUM REMOVED
1:1	29.7
1:3	60.5
1:6	67.8
1:12	87.5
1:24	70.0

Table E-31. DATA FOR FIGURE 7-52

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 3.12 Ca^{++}_o = 334.5 PPM AVERAGE FLOW RATE = 25.37 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	22.3	3.37
20	21.5	6.54
30	28.4	13.96
40	25.7	20.16
50	24.2	26.04
60	28.8	35.50
70	25.1	42.05
80	26.6	48.12
90	24.7	52.00
100	27.2	55.81
110	26.1	58.68
120	26.4	61.17
130	24.7	63.13
140	26.4	65.08
150	27.4	67.26
160	20.4	69.50

Table E-32. DATA FOR FIGURE 7-54

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 3.13 Ca^{++}_o = 290.13 PPM AVERAGE FLOW RATE = 35.66 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	29.4	11.58
20	35.2	22.34
30	41.1	34.19
40	34.9	42.18
50	32.5	51.51
60	40.3	61.90
70	37.4	68.61
80	33.2	73.77
90	35.3	77.50
100	35.7	80.16
110	32.7	82.75
120	34.3	84.64
130	37.4	87.07
140	38.1	88.57
150	37.5	89.95
160	35.6	91.10

Table E-33. DATA FOR FIGURE 7-54

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

$T = 24^{o}C$ pH = 3.15 $Ca^{++}o$ = 322.6 PPM AVERAGE FLOW RATE = 46.63 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	81.6	44.20
20	63.7	63.70
30	58.9	74.33
40	49.4	85.33
50	46.3	91.89
60	51.1	95.47
70	47.8	98.29
80	48.1	100.91
90	44.8	102.94
100	45.1	104.80
110	38.5	106.34
120	36.9	107.78
130	36.8	109.17
140	36.7	110.46
150	33.9	111.57
160	26.5	112.42

Table E-34. DATA FOR FIGURE 7-54

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 4.0 Ca^{++}_o = 331.09 PPM AVERAGE FLOW RATE = 25.14 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	21.5	11.49
20	24.8	23.06
30	25.2	34.27
40	29.3	43.32
50	21.8	49.39
60	25.0	53.13
70	22.4	55.57
80	23.6	58.05
90	25.6	60.82
100	29.3	64.14
110	25.2	66.55
120	26.9	68.55
130	25.9	70.29
140	24.4	71.56
150	28.4	72.98
160	23.0	74.13

Table E-35. DATA FOR FIGURE 7-55

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 4.0 Ca^{++}_o = 346.45 PPM AVERAGE FLOW RATE = 35.46 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	36.7	26.10
20	33.8	44.31
30	39.8	59.41
40	34.2	67.39
50	34.1	73.11
60	36.9	78.13
70	47.0	82.18
80	37.9	84.41
90	33.6	86.39
100	33.4	88.21
110	33.2	89.81
120	33.4	91.20
130	32.9	92.53
140	32.5	93.70
150	37.2	94.91
160	30.8	95.90

Table E-36. DATA FOR FIGURE 7-55

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 4.0 Ca^{++}_o = 298.2 PPM AVERAGE FLOW RATE = 57.44 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	56.5	37.58
20	62.2	59.28
30	67.3	72.93
40	65.7	79.28
50	59.4	84.10
60	59.8	88.02
70	62.3	91.31
80	61.0	94.19
90	60.0	96.89
100	58.2	99.28
110	55.2	101.33
120	53.0	103.39
130	51.6	105.14
140	49.8	106.72
150	49.4	108.20
160	47.8	109.40

Table E-37. DATA FOR FIGURE 7-55

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 5.6 Ca^{++}_o = 299.03 PPM AVERAGE FLOW RATE = 23.98 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	30.4	3.38
20	24.6	6.77
30	26.2	12.50
40	24.7	30.11
50	26.9	43.44
60	27.3	54.77
70	25.5	61.43
80	24.7	66.58
90	24.4	70.80
100	27.0	74.51
110	26.1	77.57
120	24.4	79.58
130	13.4	81.37
140	25.4	82.95
150	24.2	84.39
160	21.4	85.63

Table E-38. DATA FOR FIGURE 7-56

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 5.6 Ca^{++}_o = 264.33 PPM AVERAGE FLOW RATE = 35.06 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	33.6	22.59
20	38.6	42.06
30	33.0	54.42
40	32.7	61.21
50	36.4	68.02
60	37.5	72.96
70	23.0	76.61
80	33.0	79.65
90	37.2	82.50
100	33.0	84.81
110	33.8	86.80
120	34.6	88.57
130	50.6	90.51
140	29.4	91.77
150	35.4	93.13
160	33.5	94.36

Table E-39. DATA FOR FIGURE 7-56

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium was solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 5.6 Ca^{++}_{o} = 303.98 PPM AVERAGE FLOW RATE = 50.46 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	59.2	35.85
20	64.0	57.54
30	68.0	69.29
40	60.1	75.97
50	58.0	80.93
60	55.0	84.78
70	51.7	87.97
80	50.3	90.65
90	47.6	93.03
100	46.6	95.00
110	44.2	96.72
120	42.8	98.31
130	41.4	99.76
140	40.3	101.15
150	39.4	102.42
160	38.8	103.58

Table E-40. DATA FOR FIGURE 7-56

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.4 Ca^{++}_{o} = 325.97 PPM AVERAGE FLOW RATE = 25.23 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	20.2	12.50
20	25.4	28.49
30	30.6	40.48
40	32.6	48.85
50	25.9	54.00
60	22.6	57.99
70	21.9	61.10
80	22.4	63.84
90	24.1	66.25
100	25.0	68.28
110	26.2	70.14
120	26.5	71.94
130	26.3	74.64
140	25.7	74.64
150	27.0	75.98
160	21.2	76.84

Table E-41. DATA FOR FIGURES 7-57 AND 7-58

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.7 Ca^{++}_{o} = 341 PPM AVERAGE FLOW RATE = 34.95 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	32.2	20.30
20	38.7	42.45
30	37.0	52.79
40	36.0	59.35
50	35.7	64.31
60	37.5	68.50
70	37.5	72.08
80	36.0	75.48
90	31.3	79.45
100	35.3	82.67
110	28.8	85.36

Table E-42. DATA FOR FIGURE 7-57

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++}_o = 296 PPM AVERAGE FLOW RATE = 62.16 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	81.6	43.88
20	43.5	61.74
30	52.0	71.64
40	49.8	77.73
50	58.9	82.28
60	70.3	86.45
70	69.6	89.66
80	69.0	92.78
90	67.5	95.11
100	65.4	97.24
110	63.4	98.70
120	54.9	100.00

Table E-43. DATA FOR FIGURE 7-57

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.4 Ca^{++}_o = 190 PPM AVERAGE FLOW RATE = 24.24 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
3	76.7	16.36
6	28.0	22.68
9	25.7	28.26
12	24.0	33.36
15	22.3	38.05
18	20.3	41.20
21	20.7	44.33
24	19.7	47.18
27	18.7	49.54
30	19.3	51.73
33	18.7	53.67
36	18.7	55.35
39	19.0	56.82
42	19.3	58.19
45	18.0	59.53
48	18.7	60.67

Table E-44. DATA FOR FIGURE 7-58

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 4.3 Ca^{++}_o = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 25.4 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	25.1	4.18
20	25.8	12.14
30	26.3	16.30
40	29.7	19.50
50	24.1	22.00
60	24.8	23.68
70	23.2	25.24
80	27.9	26.57
90	24.1	27.72
100	25.5	28.73
110	22.7	29.58
120	24.5	30.38
130	27.6	31.16
140	25.2	31.83
150	25.1	32.49
160	24.7	33.10

Table E-45. DATA FOR FIGURE 7-59

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 4.3 Ca^{++}_o = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 56.3 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	67.1	17.14
20	73.0	23.02
30	68.6	26.45
40	68.2	28.84
50	66.5	30.80
60	60.8	32.29
70	61.9	33.67
80	58.3	34.97
90	47.7	36.16
100	50.1	37.09
110	48.6	38.04
120	49.4	38.97
130	45.5	39.67
140	46.4	40.37
150	44.2	41.05
160	44.8	41.70

Table E-46. DATA FOR FIGURE 7-59

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 3.0 Ca^{++}_o = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 25.33 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	27.4	13.53
20	23.4	22.58
30	22.6	29.79
40	30.4	37.85
50	24.8	42.33
60	27.3	46.39
70	27.0	49.93
80	23.0	52.74
90	25.5	55.60
100	22.6	57.95
110	24.3	60.38
120	24.4	62.55
130	24.6	64.59
140	25.0	66.48
150	26.1	68.28
160	24.9	69.91

Table E-47. DATA FOR FIGURE 7-60

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 3.0 Ca^{++}_o = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 60.83 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
10	61.2	19.96
20	54.8	32.50
30	61.6	44.48
40	59.9	52.60
50	59.2	59.77
60	59.1	66.14
70	58.1	71.30
80	65.0	76.50
90	64.8	80.75
100	64.0	84.38
110	62.5	87.26
120	60.8	89.49
130	60.6	91.41
140	60.6	93.09
150	61.2	94.72
160	59.8	96.08

Table E-48. DATA FOR FIGURE 7-60

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 5 to 8°C pH = 6.4 $Ca^{++}o$ = 304.7 PPM AVERAGE FLOW RATE = 25.4 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	25.2	19.24
30	25.2	36.25
45	25.3	48.30
60	25.9	56.47
75	26.5	63.15
90	26.6	68.71
105	24.9	73.06
120	26.7	77.70
135	26.0	81.75
150	24.4	86.39
165	24.1	90.80
180	24.0	94.72

Table E-49. DATA FOR FIGURE 7-61

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 0 to 2°C pH = 6.4 $Ca^{++}o$ = 301.7 PPM AVERAGE FLOW RATE = 61.2 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	58.7	35.93
30	65.2	54.95
45	62.9	64.91
60	59.1	72.88
75	62.3	81.04
90	60.5	87.60
105	60.1	93.36
120	58.5	98.43
135	58.7	102.93
150	63.8	107.13
165	65.1	111.20
180	59.3	114.66

Table E-50. DATA FOR FIGURE 7-61

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 5 to 8°C pH - 2.9 $Ca^{++}o$ = 337.5 PPM AVERAGE FLOW RATE - 25.0 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	25.3	22.29
30	26.7	38.38
45	27.3	49.08
60	24.1	57.04
75	28.9	63.72
90	25.4	68.67
105	26.0	73.22
120	22.8	77.06
135	26.0	80.33
150	23.6	83.67
165	22.3	86.30
180	21.7	88.62

Table E-51. DATA FOR FIGURE 7-62

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 4 to 6°C pH = 2.9 $Ca^{++}o$ - 321.5 PPM AVERAGE FLOW RATE = 59.9 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	60.8	36.43
30	58.0	52.74
45	58.0	64.15
60	58.7	71.83
75	65.3	78.41
90	57.5	83.34
105	59.6	87.51
120	60.5	91.44
135	61.7	94.89
150	60.4	97.71
165	59.5	100.24
180	58.9	102.01

Table E-52. DATA FOR FIGURE 7-62

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na.

T = 2 to 4°C pH = 5.3 $Ca^{++}o$ = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 25.1 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	26.5	8.60
30	25.5	13.45
45	25.9	17.15
60	24.5	20.00
75	24.5	22.16
90	26.7	24.05
105	24.4	25.43
120	25.3	27.06
135	22.7	28.29
150	26.3	29.50
165	23.5	30.54
180	25.0	31.39

Table E-53. DATA FOR FIGURE 7-63

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na.

T = 1 to 3°C pH = 5.3 $Ca^{++}o$ = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 59.5 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	59.5	3.52
30	59.4	7.53
45	57.8	12.10
60	60.6	17.45
75	58.9	20.94
90	58.5	23.18
105	60.6	24.95
120	60.3	26.71
135	57.2	28.09
150	60.6	29.45
165	60.9	30.87
180	59.5	32.11

Table E-54. DATA FOR FIGURE 7-63

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na.

T = 5 to 7°C pH = 2.85 $Ca^{++}o$ = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 25.3 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	26.3	14.47
30	25.2	24.55
45	28.1	33.97
60	24.1	40.63
75	23.3	46.41
90	24.7	51.78
105	23.5	56.25
120	26.1	60.61
135	26.5	64.77
150	24.0	68.65
165	27.3	72.23
180	24.0	75.37

Table E-55. DATA FOR FIGURE 7-64

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na.

T = 1 to 3°C pH = 3.0 $Ca^{++}o$ = 0 (DISTILLED WATER) AVERAGE FLOW RATE = 59.7 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	59.3	11.27
30	57.8	24.80
45	60.1	37.18
60	57.3	46.16
75	59.7	55.12
90	60.7	62.91
105	59.5	70.70
120	60.5	76.75
135	60.1	81.56
150	60.7	85.10
165	60.9	88.14
180	59.5	90.32

Table E-56. DATA FOR FIGURE 7-64

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH=6.5 Ca^{++}= 303 PPM AVERAGE FLOW RATE = 24.5 ML/MIN FOR FIRST 105 MINUTES

COAL BED DIAMETER = 1 INCH
COAL BED HEIGHT = 6-1/2 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	25.2	22.3
30	23.6	32.6
45	25.2	38.9
60	24.2	43.5
75	25.2	47.1
90	24.0	49.9
105	23.6	52.2
120	22.1	54.7
135	19.4	56.7
150	18.7	58.3
165	18.5	59.7
180	17.5	61.0

Table E-57. DATA FOR FIGURE 7-65

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 321 PPM AVERAGE FLOW RATE = 25.1 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	26.6	28.9
30	24.6	44.1
45	24.8	55.0
60	25.2	61.7
75	24.7	66.5
90	25.0	70.3
105	25.2	73.1
120	24.2	75.3
135	25.6	77.3
150	24.8	78.7
165	25.5	80.1
180	24.6	81.2

Table E-58. DATA FOR FIGURE 7-65

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 320 PPM AVERAGE FLOW RATE = 24.8 ML/MIN

COAL BED DIAMETER = 1-7/8 INCHES
COAL BED HEIGHT = 1-1/2 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	25.3	26.6
30	23.8	43.5
45	24.7	56.8
60	25.2	65.0
75	24.4	70.9
90	24.9	75.2
105	24.4	78.5
120	25.5	81.2
135	24.6	83.3
150	25.4	85.2
165	24.3	86.8
180	25.0	87.9

Table E-59. DATA FOR FIGURE 7-65

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 2 to 8°C pH = 6.5 Ca^{++} = 299 PPM AVERAGE FLOW RATE = 25.0 ML/MIN

COAL BED DIAMETER = 1-7/8 INCHES
COAL BED HEIGHT = 1-1/2 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	25.8	18.4
30	24.6	31.9
45	23.6	41.9
60	25.0	48.4
75	25.1	53.1
90	25.0	56.6
105	24.6	59.3
120	25.6	61.3
135	24.8	62.8
150	25.2	64.0
165	25.0	65.0
180	24.9	65.8

Table E-60. DATA FOR FIGURE 7-66

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 2 to 7°C pH = 6.5 Ca^{++} = 348 PPM AVERAGE FLOW RATE = 25.1 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3-1/8 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	24.4	18.3
30	25.6	31.0
45	25.9	39.3
60	24.9	45.7
75	26.5	50.4
90	24.3	54.2
105	25.6	56.8
120	24.8	59.0
135	25.8	60.6
150	24.8	62.0
165	25.3	63.4
180	24.2	64.5

Table E-61. DATA FOR FIGURE 7-66

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 346 PPM AVERAGE FLOW RATE = 59.4 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	57.1	35.6
30	60.0	51.8
45	58.0	62.3
60	59.4	69.1
75	57.7	75.2
90	60.1	79.3
105	56.7	82.2
120	63.2	84.5
135	60.0	86.4
150	60.0	88.3
165	59.3	89.7
180	59.4	90.8

Table E-62. DATA FOR FIGURE 7-67

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 327 PPM AVERAGE FLOW RATE = 59.6 Ml/MIN

COAL BED DIAMETER = 1-7/8 INCHES
COAL BED HEIGHT = 1-5/8 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	63.6	39.1
30	56.4	59.5
45	58.0	68.3
60	56.6	72.8
75	60.5	76.2
90	58.1	78.9
105	62.0	80.6
120	60.7	81.9
135	60.8	82.9
150	58.8	83.6
165	60.0	84.1
180	58.6	84.4

Table E-63. DATA FOR FIGURE 7-67

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 2 to 8°C pH = 6.5 Ca^{++} = 325 PPM AVERAGE FLOW RATE = 56.1 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	59.7	26.1
30	61.0	43.0
45	59.9	52.7
60	61.3	58.3
75	60.0	62.2
90	60.0	66.4
105	58.5	69.2
120	59.0	71.7
135	56.0	73.8
150	53.0	75.6
165	47.5	77.2
180	40.5	78.5

Table E-64. DATA FOR FIGURE 7-68

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 3 to 8°C pH = 6.5 Ca^{++} = 325 PPM AVERAGE FLOW RATE = 60.1 ML/MIN

COAL BED DIAMETER = 1-7/8 INCHES
COAL BED HEIGHT = 1-1/2 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	58.0	24.4
30	59.9	37.4
45	60.8	45.2
60	61.3	51.2
75	60.0	55.2
90	60.4	58.3
105	59.5	60.8
120	59.6	62.7
135	60.5	64.3
150	60.0	65.9
165	60.9	67.2
180	60.4	68.0

Table E-65. DATA FOR FIGURE 7-68

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -6+8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 312 PPM AVERAGE FLOW RATE = 59.9 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3-1/8 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	59.4	14.9
30	58.9	21.7
45	59.4	26.7
60	60.7	30.8
75	60.5	34.3
90	60.7	37.4
105	60.1	40.1
120	59.7	42.4
135	59.8	44.4
150	60.1	46.3
165	60.3	48.2
180	59.2	49.9

Table E-66. DATA FOR FIGURE 7-69

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -20+28 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 337 PPM AVERAGE FLOW RATE = 60.3 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	60.9	30.4
30	59.1	43.3
45	61.2	51.9
60	60.8	58.1
75	60.6	62.6
90	60.0	65.4
105	60.7	68.0
120	59.9	69.7
135	60.5	71.4
150	60.0	72.4
165	60.7	73.1
180	60.0	73.6

Table E-67. DATA FOR FIGURE 7-69

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -65+100 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 24°C pH = 6.5 Ca^{++} = 341 PPM AVERAGE FLOW RATE = 60.0 ML/MIN

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	59.4	60.4
30	59.7	80.6
45	60.7	86.0
60	60.5	88.0
75	60.4	88.7
90	60.0	89.0
105	60.0	89.1
120	58.8	89.1
135	60.5	89.1
150	60.0	89.1
165	60.0	89.1
180	60.3	89.1

Table E-68. DATA FOR FIGURE 7-69

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -6+8 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 1 to 6°C pH = 6.5 Ca^{++} = 304 PPM AVERAGE FLOW RATE = 60.0 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3-1/8 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	60.0	10.4
30	60.4	16.5
45	60.0	21.2
60	60.0	24.9
75	59.8	28.6
90	59.9	31.6
105	60.7	34.2
120	60.7	36.7
135	59.6	39.1
150	59.5	41.2
165	60.0	43.1
180	60.3	44.9

Table E-69. DATA FOR FIGURE 7-70

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -20+28 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 1 to 7°C pH = 6.5 Ca^{++} = 328 PPM AVERAGE FLOW RATE = 59.9 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 3.0 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE NA REMOVED (%)
15	59.4	15.4
30	58.6	26.7
45	61.0	34.8
60	59.6	41.7
75	58.6	47.7
90	60.1	52.7
105	60.3	57.5
120	60.5	61.5
135	60.7	65.3
150	60.3	69.0
165	59.6	71.7
180	59.5	74.8

Table E-70. DATA FOR FIGURE 7-70

Results of sodium removal from lignite by column ion exchange. Coal sample was 50 GM of -65+100 mesh lignite containing 0.36 percent Na. The calcium wash solution was prepared by bubbling CO_2 through water in the presence of calcium carbonate.

T = 1 to 7°C pH = 6.5 Ca^{++} = 311 PPM AVERAGE FLOW RATE = 60.0 ML/MIN

COAL BED DIAMETER = 1-1/2 INCHES
COAL BED HEIGHT = 2-7/8 INCHES

ELAPSED TIME (MIN)	FLOW RATE (ML/MIN)	CUMULATIVE Na REMOVED (%)
15	59.6	42.8
30	58.9	64.8
45	60.5	75.8
60	60.0	81.5
75	60.7	84.9
90	60.1	87.4
105	60.0	89.2
120	60.2	90.2
135	60.0	91.2
150	60.0	91.9
165	60.6	92.5
180	59.1	93.1

Table E-71. DATA FOR FIGURE 7-70

DATA ON CALCIUM WASH PREPARATIONS: TABLES E-72 THROUGH E-80

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 24° STIRRED SAMPLES 1330 ML/MIN CO_2 -100+150 MESH

	TIME (MIN)	Ca^{++} (PPM)
Fritted Glass	15	80.3
	30	139.6
	45	160.5
	60	186.8
	75	220.0
Open Tube	10	59.3
	20	82.0
	30	95.1
	40	123.8
	50	142.1

Table E-72. DATA FOR FIGURE 7-59

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 24°C UNSTIRRED SAMPLES 60 ML/MIN CO_2 FLOW RATE

	TIME (MIN)	Ca^{++} (PPM)
-8+10 mesh calcite	15	10.5
	30	12.2
	45	14.0
	60	17.4
	75	20.9
-28+35 mesh calcite	15	10.5
	30	14.0
	45	19.2
	60	25.3
	75	30.0
-100+150 mesh calcite	10	14.0
	20	15.7
	30	17.4
	40	17.4
	50	17.4
-325 mesh calcite	15	76.8
	30	94.2
	45	99.4
	60	109.9
	75	120.3

Table E-73. DATA FOR FIGURE 7-60

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 24° UNSTIRRED SAMPLES 1330 ML/MIN CO_2 FLOW RATE

	TIME (MIN)	Ca^{++} (PPM)
-8+ 10 mesh calcite	15	22.7
	30	26.2
	45	38.4
	60	43.6
	75	51.9
-28+35 mesh calcite	15	40.1
	30	45.3
	45	54.1
	60	61.0
	75	66.3
-100+150 mesh calcite	10	30.0
	20	34.9
	30	40.1
	40	41.9
	50	43.6
-325 mesh calcite	15	160.4
	30	188.4
	45	197.1
	60	211.1
	75	225.0

Table E-74. DATA FOR FIGURE 7-61

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 24°C STIRRED SAMPLES	60 ML/MIN CO_2 FLOW RATE	
	TIME (MIN)	Ca^{++} (PPM)
-8+10 mesh calcite	10	17.4
	20	14.0
	30	15.7
	40	20.1
-28+35 mesh calcite	10	20.9
	20	27.9
	30	34.9
	40	44.5
	50	54.1
-100+150 mesh calcite	10	38.4
	20	57.5
	30	66.3
	40	75.0
	50	85.4
-325 mesh calcite	15	174.4
	30	193.6
	45	246.0
	60	263.5
	75	284.1

Table E-75. DATA FOR FIGURE 7-62

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 24°C STIRRED SAMPLES 1330 ML/MIN CO_2 FLOW RATE

	TIME (MIN)	Ca^{++} (PPM)
-8+10 mesh calcite	10	14.0
	20	17.4
	30	21.8
	40	24.4
	50	27.9
-28+35 mesh calcite	10	22.7
	20	36.6
	30	48.0
	40	58.4
-100+150 mesh calcite	10	59.3
	20	82.0
	30	95.1
	40	123.8
	50	142.1
-325 mesh calcite	15	253.0
	30	262.0
	45	276.0
	60	302.0
	75	352.3

Table E-76. DATA FOR FIGURE 7-63

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 24°C STIRRED SAMPLES 1330 ML/MIN CO_2 FLOW RATE

	TIME (MIN)	Ca^{++} (PPM)
-100+150 mesh calcite	15	62.8
	30	92.5
	45	125.5
	60	148.2
	75	167.5
-325 mesh calcite	15	306.1
	30	275.0
	45	322.3
	60	339.0
	75	329.2
-325 mesh calcite	15	322.2
	30	329.2
	45	317.8
	60	327.9
	75	316.0

Table E-77. DATA FOR FIGURE 7-63

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 2 to 4°C STIRRED SAMPLES 60 ML/MIN CO_2 FLOW RATE

	TIME (MIN)	Ca^{++} (PPM)
-8+10 mesh calcite	15	8.7
	30	12.2
	45	12.2
	60	14.0
	75	15.7
-28+35 mesh calcite	15	10.5
	30	12.2
	45	14.0
	60	15.7
	75	17.4
-100+150 mesh calcite	15	24.4
	30	26.2
	45	30.0
	60	36.6
	75	47.1
-325 mesh calcite	15	116.9
	30	167.5
	45	216.2
	60	241.0
	75	250.5

Table E-78. DATA FOR FIGURE 7-64

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 2 to 4°C STIRRED SAMPLES 1330 ML/MIN CO_2 FLOW RATE

	TIME (MIN)	Ca^{++} (PPM)
-100+150 mesh calcite	15	37.7
	30	54.1
	45	64.0
	60	72.1
	75	83.5
-100+150 mesh calcite	15	37.7
	30	47.1
	45	59.0
	60	65.5
	75	80.3
-325 mesh calcite	15	316.2
	30	347.7
	45	346.0
	60	347.7
	75	341.0
-325 mesh calcite	15	323.0
	30	354.0
	45	349.3
	60	347.2
	75	349.3

Table E-79. DATA FOR FIGURE 7-65

Rate of calcite dissolution in water in the presence of bubbling CO_2.

T = 2 to 4°C STIRRED SAMPLES	1330 ML/MIN CO_2 FLOW RATE	
	TIME (MIN)	Ca^{++} (PPM)
-8+10 mesh calcite	15	8.2
	30	11.5
	45	13.1
	60	16.4
	75	18.0
-28+35 mesh calcite	15	22.9
	30	19.7
	45	22.9
	60	26.2
	75	31.1

Table E-80. DATA FOR FIGURE 7-65

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